NEBRASKA

GEOLOGICAL SURVEY

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NEBRASKA

GEOLOGICAL SURVEY

ERWIN H. BARBOUR, STATE GEOLOGIST

VOLUME I

REPORT

OF THE STATE GEOLOGIST

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WITH THE ASSISTANCE AND COOPERATION OF THE UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, *Director.*

LETTER OF TRANSMITTAL

To His Excellency John H. Mickey,
Governor of the State of Nebraska:

SIR—I have the honor to transmit herewith the initial report on the general geology of Nebraska.

Very respectfully,
ERWIN HINCKLEY BARBOUR,
State Geologist.

THE UNIVERSITY OF NEBRASKA,
DEPARTMENT OF GEOLOGY,
LINCOLN, JANUARY, 1903.

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PREFACE

In the preparation of this non-technical introductory report concerning the geology of Nebraska, the writer has been actuated by a desire to anticipate the wants of citizens, and to prepare something which may be useful and helpful to them; and if those who receive this paper will kindly reciprocate by correcting errors and offering suggestions, it will be helpful in turn in the preparation of future papers on special subjects.

Errors and omissions incident to initial work will be overlooked the more readily if it is known that this work has been conducted for the past ten years without compensation, and in many instances at personal expense.

Rigid economy has compelled the omission of many maps, figures, and descriptions, but as the State Geological Survey grows and comes to enjoy the moral and financial support of the people, the writer can look forward hopefully to the completion of reports of increasing accuracy and usefulness.

HISTORICAL INTRODUCTION

A history of the Geological Survey of Nebraska is briefly told, for its inauguration has been so recent that little is to be recorded. Citizens of the state, viewing the commonwealth as one rich in agriculture and poor in mines, have come to the false conclusion that a geological survey of the region is superfluous, if not wasteful. However erroneous such a conviction may be, it has served to check state appropriations for making public in printed reports the resources of which the state can boast. Prior to April, 1901, no legislative appropriations had been made, and the work of the Geological Survey was conducted at private expense. In 1891, the writer was appointed Acting State Geologist by Governor Thayer, and successively reappointed by Governors Crounse and Boyd, and by the legislature of 1893, in which year it was enacted that the head professor of geology at the University of Nebraska should be the geologist for the state, with the title Acting State Geologist. At the same time there were likewise established the offices of acting state botanist, chemist, and entomologist, all of these being purely honorary positions and carrying no salary.

The writer has willingly devoted his vacations and holidays to the state survey as a pure gratuity, his office not even being provided with stationery or postage for a voluminous correspondence, nor with any means of publishing facts and results. Citizens will therefore excuse the tardy appearance of formal reports.

Past conditions were somewhat reversed in 1899, at which time the Regents of the University of Nebraska, in recognition of the importance of a geological survey, provided that $500 be devoted to this object during the year 1899 and $250 a year for 1900, 1901, 1902.

These sums, though wholly inadequate to the work involved in so magnificent an area, were nevertheless very important, and rendered possible certain lines of investigation which otherwise could not have been conducted. In the meantime, funds varying from several hundred to one thousand dollars a year have been furnished the department of geology by the Hon. Charles H. Morrill, of Lincoln. This private aid was of great importance in supplementing the work of the State Geological Survey, inasmuch as it enabled the geologist to send parties to various regions to collect specimens of fossils, rocks, clays, limes, cements, soils, and numerous other resources.

HISTORY OF THE MORRILL GEOLOGICAL EXPEDITIONS

Through the generosity of the Hon. Charles H. Morrill, of Lincoln, the expeditions sent out annually from the University of Nebraska, known as the Morrill Geological Expeditions, have become a permanent organization of the University. Therefore it is but a fitting mark of respect that a report of these expeditions be given, in order that it may become a matter of record.

Introductory to this work, a private geological excursion was undertaken in June of 1891 by the writer, in the interest of the University of Nebraska. At this time the Daimonelix beds of our state were discovered and explored, and the Bad Lands of Nebraska and regions in South Dakota were visited, the result being that a very considerable collection was made, and several new genera and species found. In May of 1892 a second trip (likewise at private expense) was made to the Sioux county Bad Lands and to the Daimonelix beds. Again a large amount of material was secured and added to the collections of the State Museum. At this juncture Mr. Morrill proffered liberal contributions for the prosecution and continuance of the work. Then followed, during June, July, and August of the same year, the first of what has become the annual Morrill Geological Expeditions.

A well-equipped party of seven visited and collected in

the Bad Lands of the state and the Daimonelix beds, continuing thence into South Dakota and to the Dinosaur beds of Wyoming.

In 1893, a similar sum given by Mr. Morrill made possible the second annual Morrill Geological Expedition, during which collections were made in the Rhinoceros beds of Kansas, the Hat Creek Bad Lands, and the fossil Corkscrew beds of Sioux county.

During the third annual Morrill Geological Expedition, 1894, the party drove from Hot Springs to the Big Bad Lands of South Dakota, where some six or eight weeks were spent; thence to the Black Hills and beyond into Wyoming and Montana, the result of the expedition being the accumulation of a large amount of material of great variety, including fossils, minerals, rocks, etc.

In 1895 the party constituting the fourth annual Morrill Geological Expedition continued work from the Daimonelix beds and the Little Bad Lands of Nebraska to the Big Bad Lands of South Dakota, and thence to the Black Hills and beyond. This was the largest and best equipped party as yet sent into the field.

In 1896 the fifth annual Morrill Geological Expedition extended its work to eastern fields, after spending some time in the Carboniferous of Nebraska.

In the summer of 1897 the members of the sixth annual Morrill Geological Expedition again visited and collected in the Big Bad Lands of South Dakota, the Black Hills region, the Little Bad Lands, the Daimonelix beds of Nebraska, and beyond into Wyoming.

In 1898 the seventh expedition was influenced by the Trans-Mississippi Exposition in Omaha, and the museum force and assistants in the geological department became interested in the preparation of exhibits illustrating our natural resources. The quarries of the state, more particularly those of southeastern Nebraska, were visited, and important economic sets of building stones, clays, soils, etc., were added to the Morrill collections.

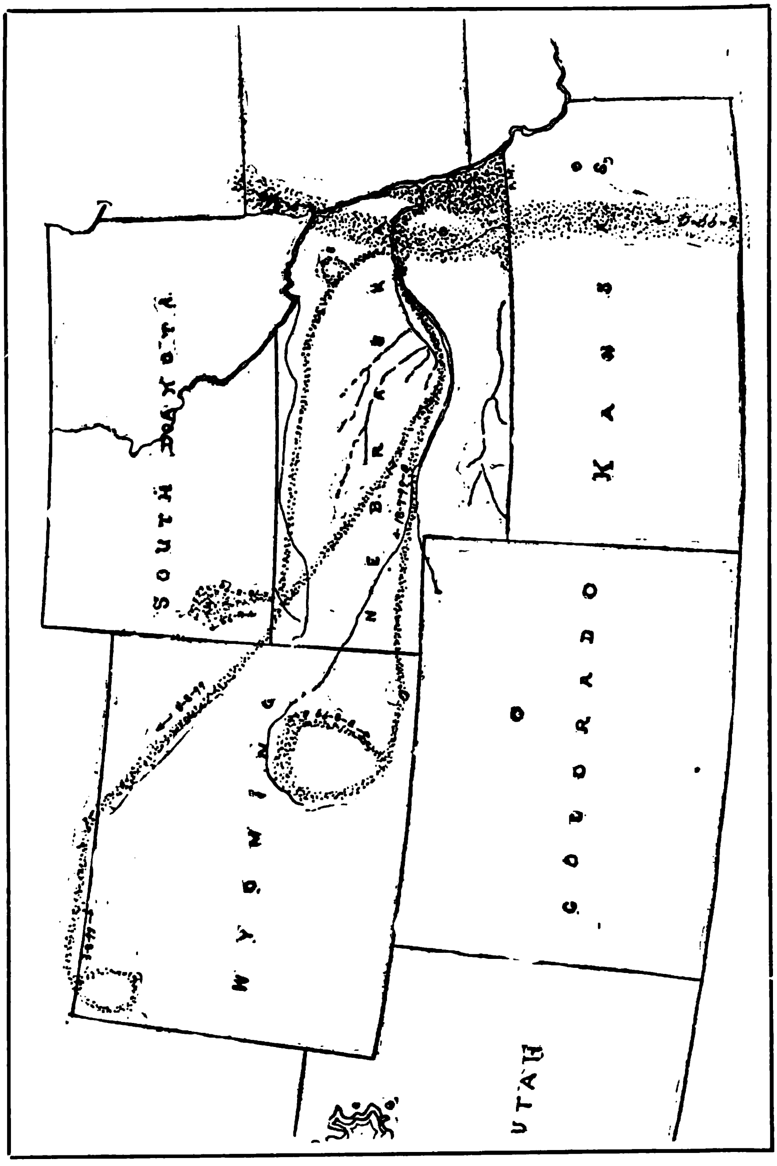


Fig. 1.—A map showing by stippling the main routes of the Morrill Geological Expeditions and the State Geological Survey for 1899. The relative amount of work done and areas covered are indicated roughly by the amount of stippling. It will be seen that the bulk of the work for 1899 was done in the southeastern corner of the state, that is, in the region of stone quarries and clay pits.

The members of the eighth expedition, 1899, were divided into five distinct parties, two of which were provided with teams and camp accoutrements, the other parties going by rail from place to place. A party of two followed the Dakota Cretaceous from Oklahoma to South Dakota. Another drove through the quarry regions in southeastern Nebraska. A third party spent the summer collecting Bryozoa in the Carboniferous. A fourth party spent some weeks collecting invertebrate fossils in the Carboniferous exposures, while the director, with an assistant, visited fields in Wyoming, Montana, Dakota, and Nebraska. Over two hundred boxes of excellent material were thus added to the collections of the State Museum. See fig. 1.

In 1900, work, though chiefly confined to the Carboniferous area, was extended beyond the state into Colorado, Wyoming, Utah, South Dakota, Kansas, and Iowa, as shown in fig. 2, and a large amount of valuable material was obtained.

In 1901 the assistants found the extraordinary heat of that summer hard to bear, and active work was soon suspended. However, the quarries along the Platte from South Bend eastward were visited. Later in the season the writer made a tour of the fossil fields and mining regions in Colorado, Utah, and New Mexico. The work of 1902 was confined to restricted areas in the Carboniferous.

The years 1901 and 1902 mark the decline of the Morrill Geological Expeditions, for the simple and sole reason that the State Museum is located in a building particularly liable to destruction by fire, and hence Mr. Morrill has decided to temporarily withhold his patronage. As it is, there is little incentive for private citizens to invest money in expensive cases and valuable specimens for their state. Such generous gifts as these, when withheld, are a loss to any community, especially since but few citizens in a commonwealth are so magnanimous as to transfer much of their private property to the state. When fire risks are so apparent, it is greatly to be hoped that the state may soon find it expedient to protect its valuable general museum and its

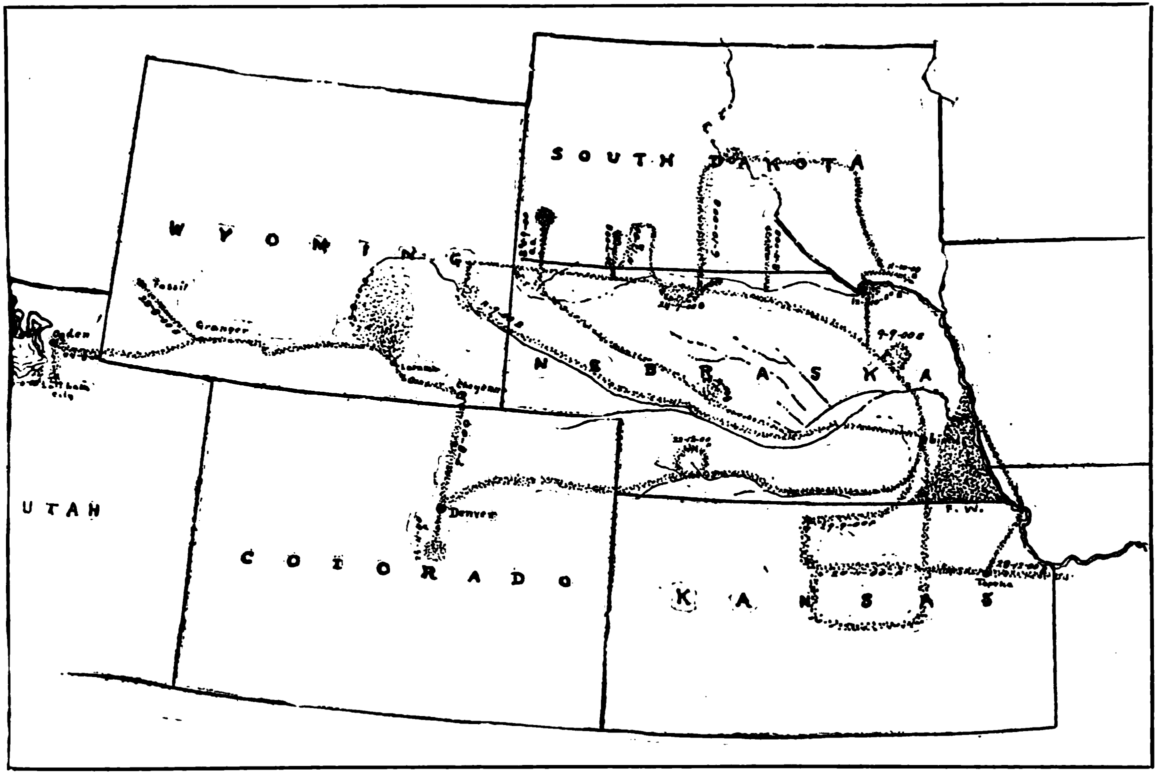


Fig. 2.—A map of the main routes of the Morrill Geological Expeditions and of the State Geological Survey for 1900. A wide area was covered and a great variety of material obtained, although the bulk of the work was confined, as in 1899, to the southeastern, or Carboniferous corner, of the state.

agricultural museum in suitable quarters. Since 1900 the Morrill Geological Expeditions have been self-sustaining by the sale of several hundred dollars' worth of duplicate specimens.

REPORT ON THE INITIAL WORK OF THE STATE GEOLOGICAL SURVEY OF NEBRASKA

In a state such as Nebraska where there is no "mineral"—a term which in the West has come to mean gold and silver—it is difficult to convince the masses that there is the least possible economic importance in a State Geological Survey.

If "mineral" did occur, apathy could much more easily be overcome, and the appeals for a survey would find more willing and receptive ears. But something stronger than apathy is encountered in the prejudice which has been engendered against a state survey by men who have sought to establish such for the evident purpose of holding office; that is, of making a political job of it. This prejudice seems justifiable; nevertheless, it is none too easy to live down.

A good many years have passed since our admission to statehood, yet Nebraska, a commonwealth greater than all New England, has never made an allowance of any kind for a state survey, not even for its unavoidable expenses, so that literally not so much as one cent has ever been voted for such work until now. Even moral support has been withheld, save that the titles acting botanist, acting chemist, and acting geologist have been conferred, these titles being the sole emoluments of office. However, the preliminary work of a survey, which has engaged the writer's attention for successive summer vacations since 1891, has recently received from the University of Nebraska encouraging recognition and an allowance, which, though small, is substantial. For the biennium of 1899 and 1900, $1,000 was allowed by the Board of Regents for the initial work of the University Geological Survey. The sum of $500 a year may seem ridiculously small, yet it made possible several lines of work. Camp outfits were obtained for several field parties, one of

which spent the summer examining gravel pits, clay pits, quarries, the water supply, and geology of the southeastern or Carboniferous counties of Nebraska. At each quarry, pit, and exposure, photographs were taken, measurements and sections made, notes recorded, and liberal samples taken from the soil and subsoil down through every layer.

One hundred and fifty localities were thus examined; the specimens obtained from each quarry were mounted in order upon large wooden tablets properly made and finished, each being seven feet high by one foot wide. These are placed permanently on exhibition to illustrate the rock and clay resources of the state. A second party, cooperating in the interest of the Morrill Expedition of that year, was provided with team and camp outfit, and drove from Oklahoma through Kansas, Nebraska, and northwestern Iowa into South Dakota, following the Dakota Cretaceous. Over one hundred boxes of material were collected, with the result that new forms were found, some valuable rock-bearing beds located, and one of the largest known collections of Cretaceous leaves made, numbering about five thousand specimens.

A third party spent the spring and summer collecting the fossil Bryozoa in the Carboniferous exposures, with the result that some thirty localities were visited and a large collection made, representing over forty species, several being new.

A fourth party visited quarries in the Carboniferous and Permian, for the sole purpose of collecting fossils. Over twenty thousand of the commoner species were procured, some of them apparently new to the state, with three or four species supposed to be undescribed. The Acting State Geologist visited all quarters of the state and attempted to correlate work as far as he was able. Freezing and pressure tests of the mortar, cement, and building rocks collected during the summer were made, and this investigation has yielded some useful, if not important, results.

In spite of the phenomenal heat of the summer of 1901,

Fig. 3

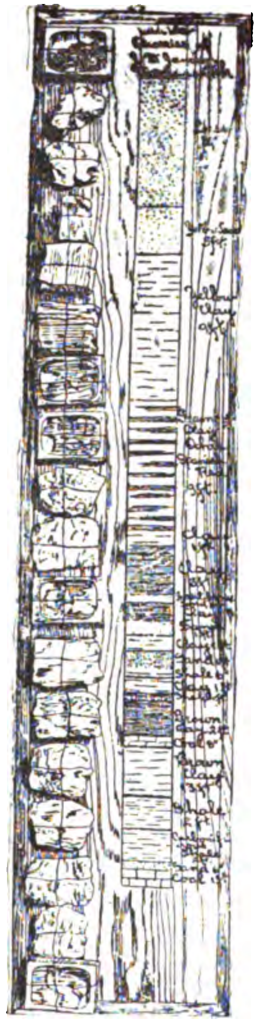


Fig. 4

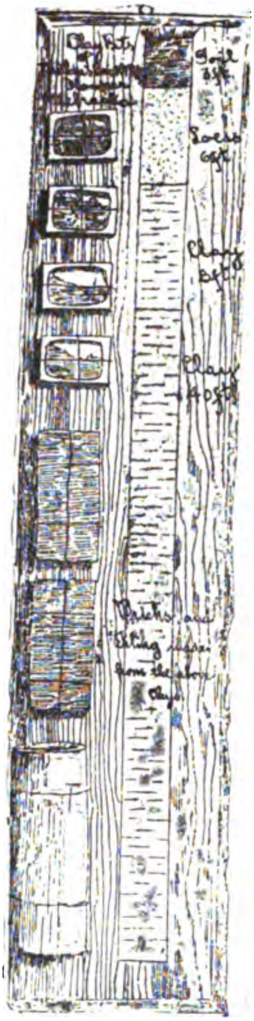


Fig. 5

METHOD OF DISPLAYING QUARRY PRODUCTS

Fig. 3.—Tablet with section of James Crawford & Son's quarry, Wymore, Neb., with samples of each layer from soil and subsoil through the loess and drift into the Permian.

Fig. 4.—Tablet with section of J. M. Jamison's quarry, Valparaiso, Neb., with samples of each layer from soil and subsoil through drift into alternating layers of lime rock and shale of the Benton.

Fig. 5.—Tablet with section of Builders' Brick Mfg. Co.'s clay pit, with samples of clay and finished products.

which was of such intensity and duration that active work in the field was finally suspended, fair progress was made. A request for funds, amounting to $1,200, for publishing the first reports of the State Geological Survey was presented to the legislature, and was passed without comment or dissent. This may be recorded as the first sum voted by the state for the examination and publication of its resources, and, though small, it helped to make possible the initial work of the State Survey.

Such field work as could be accomplished in the season of 1901 was confined to the eastern counties, where occur the greatest number of quarries, clay pits, and exposures. Likewise the work of 1902, conducted chiefly by Dr. Condra, was confined to the quarries of southeastern Nebraska, these being of especial economic importance.

Evidently sufficient time has elapsed in the history of the Nebraska Geological Survey for the accumulation of both material and facts; data and statistics have been obtained and experiments conducted, and a large number of manuscript reports prepared by the various workers of the geological staff. These are to be compiled and published as rapidly as means will allow. Among the first of these to receive attention will be a report on the building stones of Nebraska, to be followed by a similar report on the clays. Other reports are to follow in regular order until our resources, ranging from water to minerals, rocks, and soils, are made known in published form available for the use of present as well as prospective citizens.

THE STATE GEOLOGICAL SURVEY AND ITS PRACTICAL RELATION TO THE PEOPLE OF NEBRASKA

Unfortunately hitherto Nebraska has made no appropriations for the geological survey of its resources. It is often said that no other state in America has so persistently ignored the importance of making its resources known, in order that they might be developed. This results largely from the fact that coal, the baser metals, and precious ores do not occur in paying quantities. But why neglect other valuable resources? It is just as honorable to get gold from a good stone quarry as to get it from a gold mine. The money received from clay and clay products is far greater than that from the combined gold and silver mines of the United States.

Why, then, should not the state pay some attention to its extensive beds of clay, stone, cement, ochre, etc.? In that event it would come about that we need not buy so much brick of Illinois, Iowa, Missouri, and Kansas, but instead could patronize our own people. Nor would we need to ship stone from neighboring states, particularly Kansas, when precisely the same stone is lying unused in our own undeveloped quarries.

Neglect of our resources is a mistake which comes home to us the more forcibly when we see that our increase of population, at the time of the last census, was small, while that of neighboring states makes a far better showing. This has a direct relation to our undeveloped resources, for developed resources always insure stability for a commonwealth.

If the crops fail, men can find employment in the quarries, brick yards, tile kilns, lime kilns, paint works, cement works, etc., and need not be driven by adversity from our state to the quarries and mines of Kansas, Iowa, Colorado, South

Dakota, and elsewhere for employment, adding to their population and subtracting from ours. Those unfamiliar with the duties of the geologist have little idea of the amount of work done or of its close relation to practical affairs. For instance, many real estate transfers pass through the office of the state geologists, for non-residents often refuse to purchase property until the state geologist—whom they view as a fair and wholly disinterested person—has pronounced judgment upon it, and has thus given assurance that the property in question is as represented. As many as six transfers have been made in the geologist's office in a single day.

Firms in every city write to the geologist concerning places in which to locate a growing business, and also inquiring where every imaginable kind of natural resource can be obtained.

Sheep men and cattle men write from various states to learn about the conditions in this county or that. In short, in a thousand ways the work of the geological survey is closely in touch with the practical and economic interests of the people.

Six months after the first report of the geologist of Illinois was published, some eighteen to twenty thousand more persons were employed than before, due wholly, it is said, to the rapid development of resources brought to light by this one report. It had, of course, a most salutary effect upon the rapid settlement of that state.

Assuredly it is a matter of fundamental importance to this state, and can be conducted at a relatively small expense.

For the past ten years the geologist has conducted this service gratuitously, and without funds from the state with which to work. Nine summers in the field without pay, and the balance of the year devoted to the work of teaching, examining deposits for citizens, and answering a voluminous correspondence, mean hard, continuous work, rendered the more arduous by lack of funds. It is certain that when all the facts are properly presented to the legislature the Geological Survey of Nebraska will receive support.

While we all recognize that practical men, such as miners, quarrymen, clay workers, and, above all, farmers, are worthy of first consideration, inasmuch as they must blaze the way in the work of development, yet we must not ignore the needs and demands of the merchants, lawyers, doctors, and teachers of Nebraska. The most pressing demand for geological reports comes from the farmers and teachers of the state, which only emphasizes the educational as well as the practical value of all such work.

Many letters from the farm and ranch received at the office of the geologist practically amount to appeals. Sons and daughters write that they are remote from the centers of education, from reading rooms and libraries, that for prudential reasons they have been denied the benefits of higher education, but that nevertheless they have not lost their ambition to learn, and beg for state reports, even courteously offering to pay for any such which would enable them to better understand the resources of their state, and to account rationally for the phenomena around them. Teachers are constantly asking for geological reports in order to become better informed concerning the geological conditions, and thus be enabled to satisfy the various inquiries of pupils and parents.

When firms send representatives from eastern cities to the State Museum to consult the geologist and to examine the core of the Lincoln test well before taking contracts for deep drilling, it shows the work of the state geologist is eminently practical. When members of an eastern firm visit the office of the geologist to learn the nature of the ground in which they must dig, before making bids or taking contracts for setting posts and putting up woven wire fences to protect people and stock from danger from passing trains along a railroad line, you say this is practical geological work, too. But what, pray, omitting other examples, has been more genuinely practical to everyone of us than the simple education received in the public schools? The training received there is put to practical account every hour of our lives, whether we are conscious of it or not. If published reports

aid the work of public instruction, it is just as practical as the other cases already cited, and, if anything, is of wider use. These facts, though few in number, are dwelt upon to assist in showing those who have little time for considering the matter, and for weighing the evidence for themselves, that well-systematized geological reports are not simply ornamental, but are strictly useful and highly practical.

Since, throughout the world, soils constitute the basis of agricultural wealth, and ores constitute the metallic basis of our civilization, whichever way we turn we are invariably led back to the earth as the ultimate source; hence that science which aids in the understanding of the earth is peculiarly and fundamentally practical.

During the past two years several reports have been prepared by the department of geology touching the clay and quarry products, yet funds have not been available for the publication of such works, no matter of how much economic importance they may be. This should have attention, for it is important that quarrymen, builders, contractors, and citizens should have some way of learning about our rock and clay, what pressure they will stand, whether or not they weather well, whether they break down under freezing and thawing, whether there is iron pyrite present to disfigure buildings with rust, etc. All the quarries in the state either have been or will be visited, sections and drawings made, and samples of rock, clay, sand, etc., taken, showing what can be found in each and every layer in every quarry and clay pit. The samples already secured are to be seen in the Museum of the State University at the present time, where they can be examined by citizens living in or near Lincoln, but for others they are useless until properly described for the people.

Freezing, thawing, and pressure tests have been made of our building stones, and the results, with all kinds of instructive and suggestive illustrations, are ready for publication. Pressure, freezing, thawing, and "rattler" tests are being made of the bricks of the state, and these results, when published, can but be of value to the people who wish to build.

All the various undeveloped resources of the state are being studied, and a number of reports are ready for the state printing board.

Another useful end which is served by such publications is the great saving to men who squander large sums in prospecting for oil, coal, gold, silver, and other ores, where none exist. In 1896 over twenty thousand dollars were spent in the eastern half of Nebraska prospecting for coal and natural gas alone. One man spent $5,000 in this way during that season. The sum total of the money and time spent in aimless prospecting in Nebraska can not fall much below fifty thousand dollars annually. A few simple reports would save all of this loss.

Men can be found in every county who devote more or less valuable time to the work of prospecting without having even the most meager working knowledge of the subject in hand. All such work is done at a heavy loss, and could be avoided if they were possessed of the proper information. Men are daily prospecting for coal in Nebraska in regions where numerous deep wells show positively that coal can not be found, yet they dig away cheerfully. It is just as much the duty of the state geologist to inform people how to avoid squandering their money on useless prospecting as it is to make valuable resources known. This can only be done by making the people familiar with our resources through the medium of published reports.

Prospecting in Nebraska results in a very serious loss to many over-zealous and over-confident people. Oil, coal, gas, gold, and silver excite their attention, and nothing can dissuade them from devoting their time and property to the end of developing resources which they believe to be there. Many a farm has been sacrificed in ambitious attempts to find impossible things in impossible places. It is often pitiable, especially in the case of foreigners, who, on consulting a geologist, command so little English that an interpreter is necessary, and even then they fail to fully explain themselves or to understand explanations which are offered.

In certain places large numbers of Russians, elsewhere Bohemians, Swedes, and people of other nationalities, possess large tracts. In every such settlement one invariably finds a foreign miner or two who assures the people of his nationality that the surface configurations resemble those around the coal mines in the old country, the direction of the fences, and the growth of the bushes and vines is identical, also the occurrence of dark clays and shales. No amount of advice can shake their faith in the discernment of this practical man, and we have known these same foreigners, who make most honorable and prosperous citizens, to sacrifice their farms and homes in their determination to prove their theories about the existence of coal in their region.

This is not confined to our foreign population, for few of them are employed in such useless and unprofitable pursuits as our own people, but they are mentioned in particular, because their case seems all the more unfortunate when everything is lost through a foolish infatuation. When men have their minds made up it is all the harder to reason with them in a strange tongue, and they will not be convinced of the inutility of their undertaking. If one begins to show them why coal, oil, gas, or the precious ores are not to be expected, immediately his hearers begin to suspect his motives, and the charge is preferred over and over again that in giving such advice the members of the Survey are acting in the interests of railroads or other corporations, and this acts as a stimulus to greater activity on the part of the prospector. We have known parties to sink shafts as far as they could dig or drill, at expenses varying from a few hundred to five thousand dollars, and, after actual experiments showed them that nothing could be found, they cheerfully dug a second, third, and fourth time, all within an acre of ground, and at a total loss. All of this waste was directly owing to some practical miner who based his judgment on such things as slope of ground, in blissful ignorance of evidence, and lack of proof from deep borings and wells in his vicinity, and who was totally uninformed of the geology of the place or the laws which govern deposits.

Sometimes it is arranged that the expenses shall be prorated; hence the burden of the cost falls not upon the individual, but upon a community of farmers. This arrangement, though wasteful and sadly misguided, is not so apt to lead to financial embarrassment. When the individual ventures to assume financial risks to the amount of several thousand dollars, it is too apt to mean a mortgage on his property, which often foreshadows bankruptcy. These cases come so frequently under the observation of a state geologist that he is strongly inclined to speak feelingly on the subject. Finding everything lost, or in danger of foreclosure, appeal for aid is made to the governor or to the state university. But no funds are provided for the prosecution of private mining ventures, especially in a state so peculiarly agricultural.

A prospect hole, though costing several thousand dollars and yielding nothing material in return, is not to be viewed as a total waste of good money, for it furnishes the geologist with valuable information concerning the strata passed through, and warns the community of the inutility of neglecting regular avocations, and hazarding property and time in mining schemes in regions where it can be foretold, without the expenditure of a dollar, that the undertaking must end in disappointment and failure.

Cases have been known in Nebraska where individuals have spent as much as twenty thousand dollars each prospecting for coal, chiefly in the Pierre shale, which is destitute of coal. The shales of the Pierre and Benton are dark, to be sure, but so are many other barren beds dark. A dark color is not proof nor even evidence of coal, and no one is justified in following his own fixed belief, basing his judgment on so superficial a thing as color or texture. No one can afford to found a costly enterprise on mere hope.

Numerous small companies are organized annually to drill and dig, and yet this long-continued, strenuous, and costly effort, though yielding a little negative information, has produced nothing material as yet. Probably no two years have

witnessed the launching of more mining schemes than those of the past biennium, companies having been formed in most of the towns of any size in the state. The bulk of such enterprises is reported from the eastern and southern edges of the state, very few being found in central, northern, or northwestern Nebraska. Probably the wise and liberal bounty offered by the state for the discovery of a good workable bed of coal is responsible, in part, at least, for the coal fever. At any rate, samples of "coal" are often submitted at the office of the State Geological Survey and the bounty claimed. It should be explained that most of this is not coal at all, but simply a dark carbonaceous shale which would serve for brick better than fuel.

Though exact figures are never obtainable, yet the Geologist feels warranted in reporting more than one hundred thousand dollars involved in the mining ventures of this state during the past two years. To add to the expense, a good many people have employed mining experts to travel from Chicago, Denver, and elsewhere to pass on "coal propositions" in Franklin and other counties where coal is least to be expected. If this were productive employment of capital, less would be said, but as it is we must regret this misuse of good money, and regret more than ever that more funds are not available for the furtherance of the geological survey, in order that it may do the double duty of checking needless expenditure in prospecting, and of making known the state's resources for those who wish to aid in developing them. It can not be gainsaid that enough money is spent each year in useless prospecting to make a superb survey of the state as a whole, and enough is wasted in ten years to make an exact survey by counties.

The gold excitement has claimed many victims in Nebraska as well as in Iowa, Kansas, and Missouri during the past few years. As nearly as the writer can learn, this has been fostered by certain concerns outside of the state. Still, it has resulted in a great deal of disturbance of the peace and quiet of many places. Nearly every town from Milford west-

ward has had its excitement, and the papers of the state have made lengthy reports on the rich placer diggings of Nebraska. Of course, there is some gold in the state, and it is interesting to know the fact, but it is gold in commercial quantities, rather than interesting occurrences of it, which affects a commonwealth.

PHYSIOGRAPHY

GEOGRAPHICAL POSITION

It may be mentioned briefly for the instruction of prospective citizens, and for others unfamiliar with Nebraska, that, in point of size at least, it ranks with the largest states in the Union. It is a grand expanse of country, rivaling an empire in size, situated in the geographical center of the United States proper, extending northward from the fortieth to the forty-third degree of north latitude, and westward from the ninety-fifth to the one hundred and fourth degree of longitude, west from Greenwich, measuring in miles 208 from north to south, and 440 from east to west, and including within its boundaries 77,000 square miles (49,000,000 acres). This exceeds the area of all New England by 11,000 square miles.

It is bounded on the north by South Dakota, on the south by Kansas and Colorado, on the east by Iowa, from which it is separated by the Missouri river, and on the west by Colorado and Wyoming.

It may not be out of place to mention just enough of the history of Nebraska to show that it was included within Louisiana, ceded to the United States by France, April 30, 1803; explored by Captains Lewis and Clark, 1804; organized as a territory with certain extensive Indian reservations in 1854, when settlement began; had a population of 28,841 by 1860; admitted to the Union as a state on March 1, 1867, with a population of 60,000, and at the present writing has a population of over 1,066,300.

Those who have traversed the state in all directions find its possibilities commensurate with its magnificent distances, although a wholly different impression was formed of this region in the outset. Then it was viewed as a desert,

but the conditions which conspired to make it such have completely changed. Then it was a region trampled by herds of such size that 500,000 buffalo have been counted in a single band. The result of such vast herds was over-grazing and trampling, which damaged and killed the grass, especially during periods of drouth. Insects which are destroyed by continued cultivation, and which are very injurious to vegetation, were unrestricted, and nothing can exaggerate their numbers or their ravages. The tribes were accustomed to burning the prairie grass, which added to the work of destruction, and left the ground bare and exposed to the sweeping wind, converting the region into one of creeping and shifting sand dunes.

Settlers can still remember when this was true of Kansas and Nebraska, and the very regions in these two states which were wandering sand dunes in their day are now so well set with valuable grasses that a shifting sandhill is worthy of comment even in the heart of the sandhill region. Times have changed, and with them the western desert to such an extent that where once the sandhills were worst, now the grazing lands are best, and where the desert was now there are not only grazing lands, but farms and homes, villages and towns.

TOPOGRAPHY

The surface configurations of Nebraska and the general relief of its surface are very unlike the popular conception of a prairie as being level as the floor. Though very level in places, it is surprisingly rolling and even broken elsewhere, or cut into canyons, ridges, and buttes. Instead of the monotony of scenery which the tourist pictures to himself there is found a surprising diversity. Mountain scenery is beautiful, it is true, but there is nothing much more profoundly impressive than the vast stretch of the ocean and the great billows of the prairie. It is magnificent and inspiring to such a degree as to make it seem unquestionable that the unmeasured outlook of the great plains must broaden

the minds of its inhabitants infinitely more than can be the case with those who live in places so hemmed in as to be necessarily narrowing in their influence.

While there are no mountains within the state, it must not be forgotten that the entire western half of Nebraska is mostly mountain high, and that there are hills and ridges of great ruggedness to diversify the landscape, Pine Ridge being 4,000, and Wild Cat mountain 5,300 feet high.

The lowest point is the water level of the Missouri river in the southeastern point of Nebraska, the altitude of which is eight hundred and ten feet. Thence to the westward the state rises at the nearly uniform rate of, say, eight or ten feet

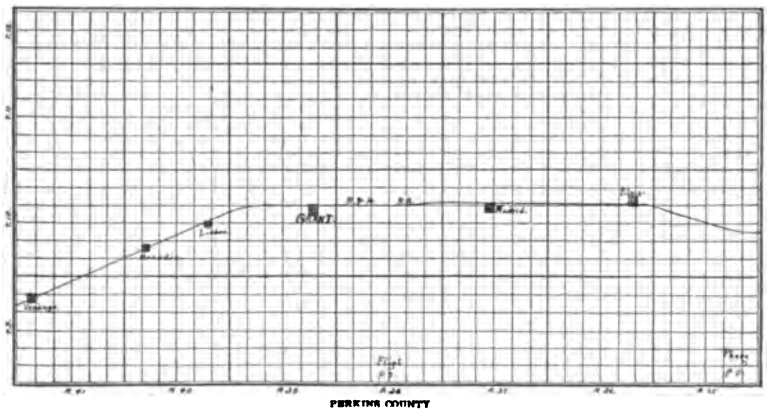


Fig. 6.—A map of Perkins county, Nebraska, used as an example of the type of map which has been standard in the state for years. Erase the imaginary lines and little or nothing remains. Such maps convey no information to resident or prospective citizens, and yet they must be used until the geologic and topographic survey can replace them by accurate maps. Compare this map with the one represented in Fig. 7.

to the mile. Thus, one passes insensibly from 1,000 to 5,000 feet of elevation above sea level. The elevations as we go westward approximate closely to 1,000 feet of elevation for each 100 miles. The grade is six feet per mile for the first hundred miles, seven feet for the second hundred, eight for the third, ten for the fourth, and eighteen to twenty for the last fifty miles. Along the eastern border the ascent is very

gradual, being but a foot or so to the mile. Along the western border it is several feet to the mile as one passes northward.

TOPOGRAPHIC MAPS OF NEBRASKA

It is often of great importance to have exact maps of certain regions, so, in the interest of teachers, business men, and farmers, it should be explained that the United States Geological Survey has made arrangements whereby any person can procure these maps. This is a most advantageous arrangement since it enables all of us to become possessed of maps of the utmost accuracy, and which, though costly, are furnished at a nominal price.

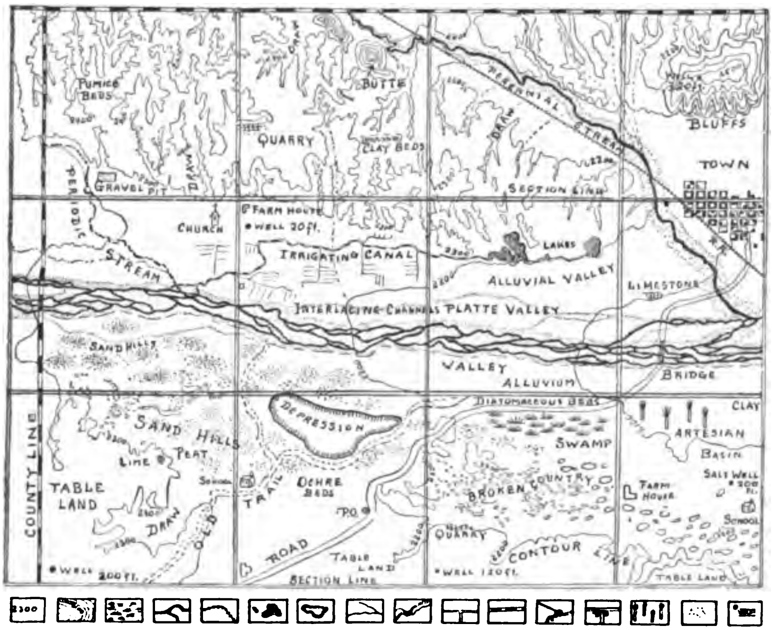


Fig. 7.—A map showing in a simplified way, and without colors, the main features of maps produced by the United States Geological Survey and for use by the State Geological Survey. Such maps as these furnish exact information for guidance of resident and prospective citizens alike. Compare with fig. 6. These maps show the elevations and depressions of the surface; the rivers; the perennial and periodic streams; the artesian basins, wells, springs, lakes, and even the marshes. All roads, trails, irrigating canals, quarries, clay pits, gravel pits, and other deposits are correctly shown, thus furnishing a fund of exact information.

The United States Geological Survey has been engaged since its organization in making a topographic survey and map of the United States. The unit of survey is a quadrangle 15′, 30′, or 1° in extent each way, covering an area of one-sixteenth, one-fourth, or one "square degree." The unit of publication is an atlas sheet 16½ inches wide by 20 inches high, and each sheet is a topographic map of one of the above

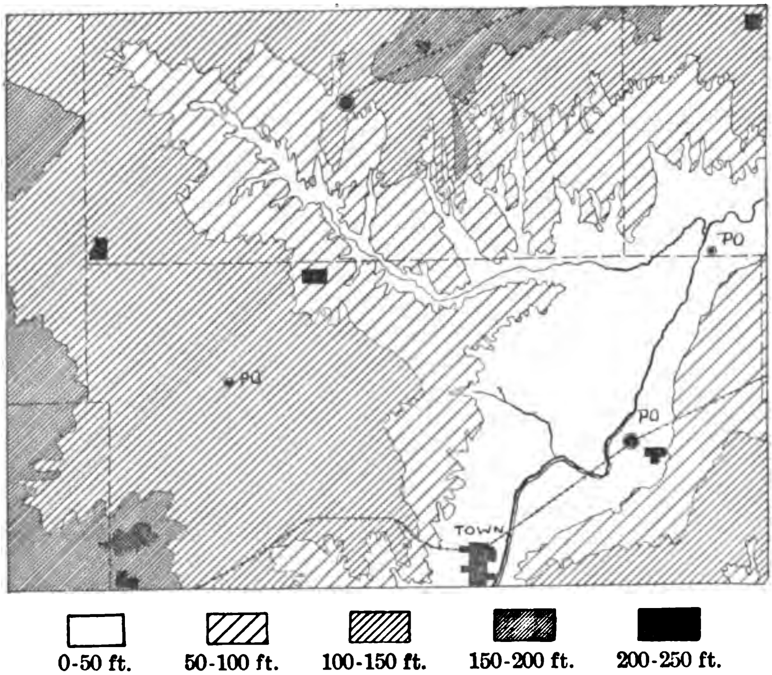


Fig. 8.—A map showing several farms, with draws and streams, etc. By means of such a map as this a farmer can tell even the depth to water on any part of his farm. This figure, coupled with fig. 7, will help to show the general plan of the maps of the United States Geological Survey, which are available for use in the State Survey.

areas. The scale of the full degree sheet is 1:250000, that of the 30′ sheet is 1:125000, and that of the 15′ sheet 1:62500. A sheet is designated by the name of some well-known place or feature appearing on it, and the names of adjoining published sheets are printed on the margins. The maps are engraved on copper and printed from stone, in three colors.

The cultural features, such as roads, railroads, cities, towns, etc., as well as all lettering, are in black; all water features are printed in blue, while the hill features are shown by brown contour lines. The contour interval varies with the scale of the map and the relief of the country. Maps of limited areas economically important are sometimes published which are not in conformity with the general scheme outlined above; these are called *special maps.*

The progress of this work in Nebraska is shown on the index map, fig. 9, where the large rectangles represent 30′ sheets and the smaller ones 15′ sheets. Each of the former shows a tract (quadrangle) 30′ in extent each way (one-fourth of a "square degree"), or about 880 square miles, the area varying with the latitude. The scale is 1:125000, or about 2 miles to 1 inch, and the contour interval is 20 feet. Each of the sheets represented by the small rectangles shows a quadrangle 15′ in extent each way (one-sixteenth of a "square degree"), or about 220 square miles. The scale is 1:62500, or about 1 mile to 1 inch, and the contour interval is 20 feet. The small rectangles occurring within the larger ones, on the index map, indicate that sheets on both scales have been published for those areas. The whole number of sheets published is 36.

An act of Congress approved February 18, 1897, prescribes that the maps shall be disposed of by sale. They are sold at the rate of *five cents a sheet* of standard size. For 100 or more in one order, whether of the same sheet or of different sheets, the price is *two cents a sheet* for the standard size. Special maps and those of larger size are sold at proportionate rates and same conditions of discount. Prepayment is required, and may be made by money order, payable to the order of the Director of the United States Geological Survey, or in cash—the exact amount. Checks and postage stamps can not be accepted.

When maps ordered are not in stock the right is reserved to substitute other sheets, rather than return very small sums of money by mail, unless directions to the contrary are given in the order.

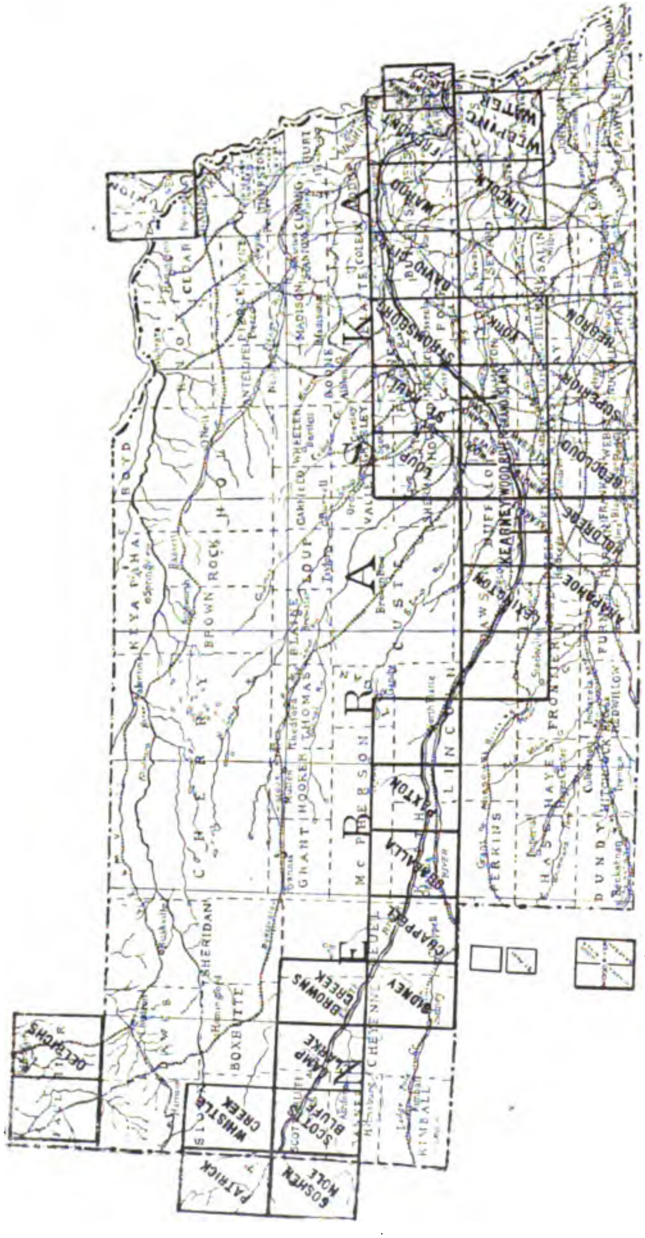


Fig. 9.—Index to topographic atlas sheets of Nebraska prepared by the United States Geological Survey.

Similar topographic surveys have been made in other states, and maps are likewise obtainable of the United States Geological Survey on the same terms. Ranchmen and others doing business both within and beyond the state may find it advantageous to procure occasional maps of certain regions in neighboring states.

Among the sheets shown on the index map is the following special sheet: Omaha and vicinity, Nebraska-Iowa.—This map covers an area of about one-eighth of a "square degree." Its size is 22 x 31 inches. Scale, 1:62500, or about 1 mile to 1 inch; contour interval, 20 feet. In the summary (given on first page) of number of sheets this map is counted as two sheets. Price, 10 cents. In lots of 50 or more the price is 4 cents each, but the reduced or wholesale rate is not allowable on orders for maps amounting to less than $2. This enables teachers and business men of Omaha and vicinity to procure maps of the highest grade at a small cost.

Maps of the United States are also to be had in a similar manner.

A wall map (in three sheets), size 49 x 76 inches, on a scale of 40 miles to an inch, approximately. This map is published either with or without contours. Price, 60 cents; 100 or more, 24 cents each.

A small map, 18 x 28 inches, on a scale of 111 miles to an inch, approximately; published either with or without contours. Price, 10 cents; 100 or more, 4 cents each.

A hypsometric map, same size, scale, and price as next above.

A small base map, 11 x 16 inches, on a scale of 204 miles to an inch, approximately. Price, 5 cents; 100 or more, 2 cents each.

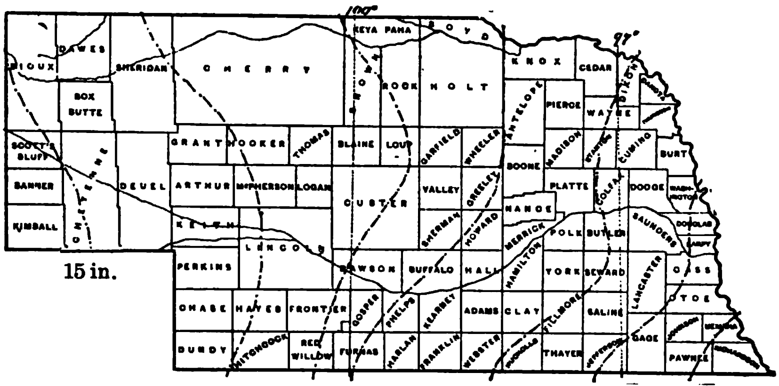
While no geological folios of Nebraska have been published as yet by the United States Geological Survey, it is well to make the fact known that many folios of other regions are in print and are obtainable.

Geologic maps corresponding in position and area with

the topographic maps are being published in the form of folios. The areal geology, underground structure, and mineral deposits are represented by colors and patterns. No folios covering quadrangles in Nebraska have as yet been issued, although several are in preparation. A general circular on geologic folios may be had on application to the United States Geological Survey.

Any correspondence relative to maps or folios should be addressed to The Director, United States Geological Survey, Washington, D. C.

"Arid" Semi-arid Humid



Precipitation, 18 in. 21 in. 24 in. 27 in. 30 in. 33 to 36 in.
Evaporation, 6 ft. 5 ft. 4½ ft. 3 ft.

Fig. 10.—A map of the state showing above the regions known as humid, semi-arid and "arid" (there is no strictly arid region within the state), showing below the precipitation and evaporation. The average precipitation is 23.33 inches a year. The average evaporation 4½ feet.—After Swezey and Loveland.

CLIMATE

The climate of a country bears a close relation to its hydrographic, agricultural, and sanitary conditions, and a brief synopsis of our climate must not be omitted in this connection, especially since it admits of the correction of errors, which, though of long standing, are as misleading as they are detrimental to the reputation of the state.

The attention of readers is directed to the very favorable

report entitled "The climate of Nebraska, particularly in reference to the temperature and rainfall and their influence upon the agricultural interests of the state." Ex. Doc., No. 115, 51st Congress, 1st Session, 1890.

It is said that Nebraska, lacking mountain ranges and large forests, has the physical conditions which insure a homogeneous climate. It is strictly an inland or continental climate, being 1,600 miles from either ocean, 800 miles from the Gulf of Mexico, and 500 miles from the Great Lakes. "In contradistinction to marine climate the term implies, for Nebraska, winters of considerable severity, summers of unusual warmth, rainfall in limited quantities, marked and sudden changes of temperature, large seasonal and daily temperature ranges, and dry, salubrious atmosphere, with a small percentage of cloudiness, and a large percentage of sunshine."

Nebraska is the geographic center of the United States proper, and, considering its remoteness from the sea, its climate has characteristics which are remarkably constant.

PRECIPITATION.—The moisture precipitated as rainfall over Nebraska is derived directly or indirectly from the Gulf of Mexico. The variation in rainfall in different sections of the state exerts a strong control over the character of creeks and rivers, plant and animal life, and the activities of man in the respective regions. Nebraska is much more favored in the matter of precipitation than is generally known, the annual rainfall of the state being over twenty-three inches, distributed as shown in fig. 10.

Nebraska has an advantage over many states in that the rainfall is most plenteous at the critical months for agriculture, namely, April, May, June, and July.

This is one of several causes which enables Kansas and Nebraska to raise phenomenal crops (against which other states can not compete) on a limited precipitation, so limited as to produce drouth and complete crop failures in the eastern states.

Professors Swezey and Loveland, in Bulletin 45 of the

Agricultural Experiment Station of Nebraska, have shown that, of the 23.33 inches of annual rainfall in Nebraska, 16.08 inches, or 69 per cent of the entire amount, falls during the five months of the growing season, April to August, inclusive. In order to show how we compare in this respect with other states the following table is introduced. It shows what per cent of the total yearly rainfall occurs in these same five months in other localities:

TABLE SHOWING THE MONTHLY PRECIPITATION IN NEBRASKA

		INCHES	NO. OF RAINY DAYS
January		0.68	6.3
February		0.71	5.7
March		1.16	6.5
April	Growing season	2.40	9.2
May	Growing season	3.60	12.1
June	Growing season	3.93	10.2
July	Growing season	3.51	9.9
Aug.	Growing season	2.62	8.5
September		1.84	6.6
October		1.49	6
November		0.68	4.1
December		0.69	6

16.08 in. or 69 per cent of the annual precipitation falls during the growing season. 90 per cent of it soaks in.

RAINFALL DURING THE GROWING SEASON IN VARIOUS LOCALITIES

STATION	PER CENT
St. Louis, Mo	48.00
Cheyenne, Wyo	71.00
Dodge City, Kan	73.00
North Platte, Neb	72.00
Omaha, Neb	67.00
Huron, S. D	74.00
St. Paul, Minn	61.00
Duluth, Minn	57.00
Davenport, Iowa	55.00
Keokuk, Iowa	54.00
Nebraska in general	69.00

It thus appears that the states of Nebraska, Kansas, Dakota, and Wyoming, with their none too plenteous supply of rainfall, have, on the other hand, the advantage over the

states lying farther to the east that a large percentage of this rainfall occurs in the growing season, when it is most useful, and that as we go eastward the percentage gradually falls off, particularly toward the southeast, or, in other words, in the direction toward which the actual amount of rainfall increases most decidedly; so that if we compare the rainfall of the growing season alone in the different localities, Nebraska does not appear in so unfavorable a light as her small yearly rainfall would indicate.

TABLE SHOWING THE ANNUAL PRECIPITATION IN NEBRASKA AND NEIGHBORING STATES

	INCHES
Indiana, to 1894 inclusive,	39.70
Illinois,	38.05
Iowa	34.88
Kansas	26.67
Kentucky,	45.60
Michigan, to 1896 incl.,	30.83
Missouri, to January, 1895,	37.74
Nebraska	23.33
6 New Eng. States, to 1896	44.51
New York,	37.52
North Dakota,	18.88
Ohio, 15 years to 1896, incl.,	39.46
South Dakota, to 1896, incl.,	19.97
Wisconsin,	32.06
Wyoming, 5 years, 1896, incl.,	13.35

The eastern part of Nebraska during these four important growing months has a larger amount of rainfall than the eastern states from Maine to Virginia, and the western part of the state is favored with a rainfall but slightly below the amounts recorded in the eastern states.

While it is established that the amount of precipitation is not increasing, yet it is becoming better distributed throughout the year. "If this characteristic, brought out from later records, is to be accepted as a fact, such increase may be accounted for as resulting from increased cultivation, breaking up of the soil, and not the least, perhaps, from the fact that the planting of trees has been so greatly stimulated by the observance of Arbor Day, which the peo-

ple of Nebraska inaugurated and have been most faithful in maintaining."

RAINFALL DURING THE GROWING SEASON, APRIL, MAY, JUNE, AND JULY

STATES	INCHES
Eastern N. Y., Albany	13.51
Central N. Y., Rochester	11.81
Eastern Pa., Philadelphia	13.02
Central Pa., Pittsburg	14.23
Maryland, Baltimore	14.90
Virginia, Lynchburg	13.73
Eastern half of Nebraska	14.48

TEMPERATURE.—The temperature decreases as one goes from south to north, and likewise in going from the lower altitudes of the Missouri river front to the higher altitudes of the western boundary. The annual average temperature of the state is 46° to 50°. During July, the critical month for ripening grain, the average temperature ranges from 74° to 77°.

EVAPORATION is facilitated by our relatively high summer temperatures, the prevalence of moderate winds, and the lack of aqueous vapor in our atmosphere. The evaporation for the state is shown in connection with its precipitation in fig. 10.

FROSTS, such as kill ordinary farm vegetables, cease about the middle of April in eastern Nebraska, and as late as the middle of May in northwestern Nebraska. The first killing frost occurs about the middle of September, although in southern and southeastern Nebraska the time is postponed until October 1 to 10. Hence, in this respect Nebraska is equally favored with the extreme southern parts of Illinois, Ohio, Indiana, Maryland, and Pennsylvania.

SUNLIGHT has an important relation to health as well as to agriculture, and Nebraska is counted a favored state as regards the amount of sunlight, particularly during the season when staple crops are ripening for harvest.

WINDS in Nebraska accord far more closely with the aver-

age for the United States than is generally known even by our own citizens; the average at Omaha is eight miles, at North Platte nine miles, at Valentine eleven and three-tenths miles.

Contrary to accepted belief, Nebraska is reported by the Weather Bureau at Washington as being so situated with reference to storm centers as to be rarely visited by tornadoes, the few which have occurred being confined to the Missouri river region. They are pronounced less destructive in Nebraska than thunder storms. The greater portion of the state is situated in the westerly quadrants of low area storms, so the state almost entirely escapes the devastations of whirlwinds.

HYDROGRAPHY

As a hydrographic basin Nebraska presents many features of interest, and some of sufficient importance agriculturally to warrant special study in special reports. Perhaps no single question since the drouth of 1894 has engaged the serious attention of citizens at large as much as that of water. In a state, the most distinctly agricultural of any in the Union, where the soil is of extraordinary depth and of the most undoubted fertility, and where the rainfall is a trifle scant, the water problem becomes foremost in agriculture. Anything helping to solve this water problem in central and western Nebraska determines its agriculture. Nothing else is lacking. This seems to be the concensus of opinion of our practical farmers and business men.

Such being the facts, no better work is before the geologist than the study and full understanding of all the conditions of our broad hydrographic basiñ. Accordingly, the University of Nebraska is measuring and gaging all streams and lakes, and determining the amount of rainfall, the run-off and evaporation over the state, the underground waters and the possibility of utilizing them for purposes of irrigation. The amount of rainfall caught and retained in our soil is very high, for the run-off is but one-tenth.

However, there is neither space nor available means for considering these problems at this time, except in a very general way. Later on as work progresses and comes to receive material support, the matter will be reported in detail.

At present we must confine our attention to certain main features of our streams and rivers, whose history antedates that of the mountains through which they cut. Some may be called fossil rivers; that is, the channels through which they formerly flowed, with their sand bars, gravel, pebbles, and boulders, have been turned into stone. By means of the fossilized channels the North Platte and its tributaries may be traced for miles in western Nebraska. The coarseness of the material is indicative of the size and the position of the river gravels, while the buttes show the former level of the streams, which was much higher than at present. In a like manner the terraces of the North Platte tell of its former size. The upper terrace tells of a deep, broad stream, powerful enough to carry coarse pebbles and boulders. Stepping down to succeeding terraces, the material grows finer and the channel narrower, until we come to the river as it exists to-day. This is a hint at the ancient history of our rivers which will make an interesting chapter some day.

Of our present rivers the Platte and Missouri have their sources in the Rocky mountains, while all the others rise in the great plains. Most of our streams are perennial and furnish water the year around; but a few dry up in whole or in part during seasons of drouth. As a third class may be named those which have no outlet, but which flow a certain distance and then disappear by sinking and evaporation.

Elevations at different points determine in part the velocity of streams and hence their power to reduce and transport rock. On steep slopes streams cut deep valleys and carry away all loosened particles. Where the slope is slight they deposit sediment.

No one can fail to be impressed by the southeasterly courses of the rivers of this region, and by their parallelism,

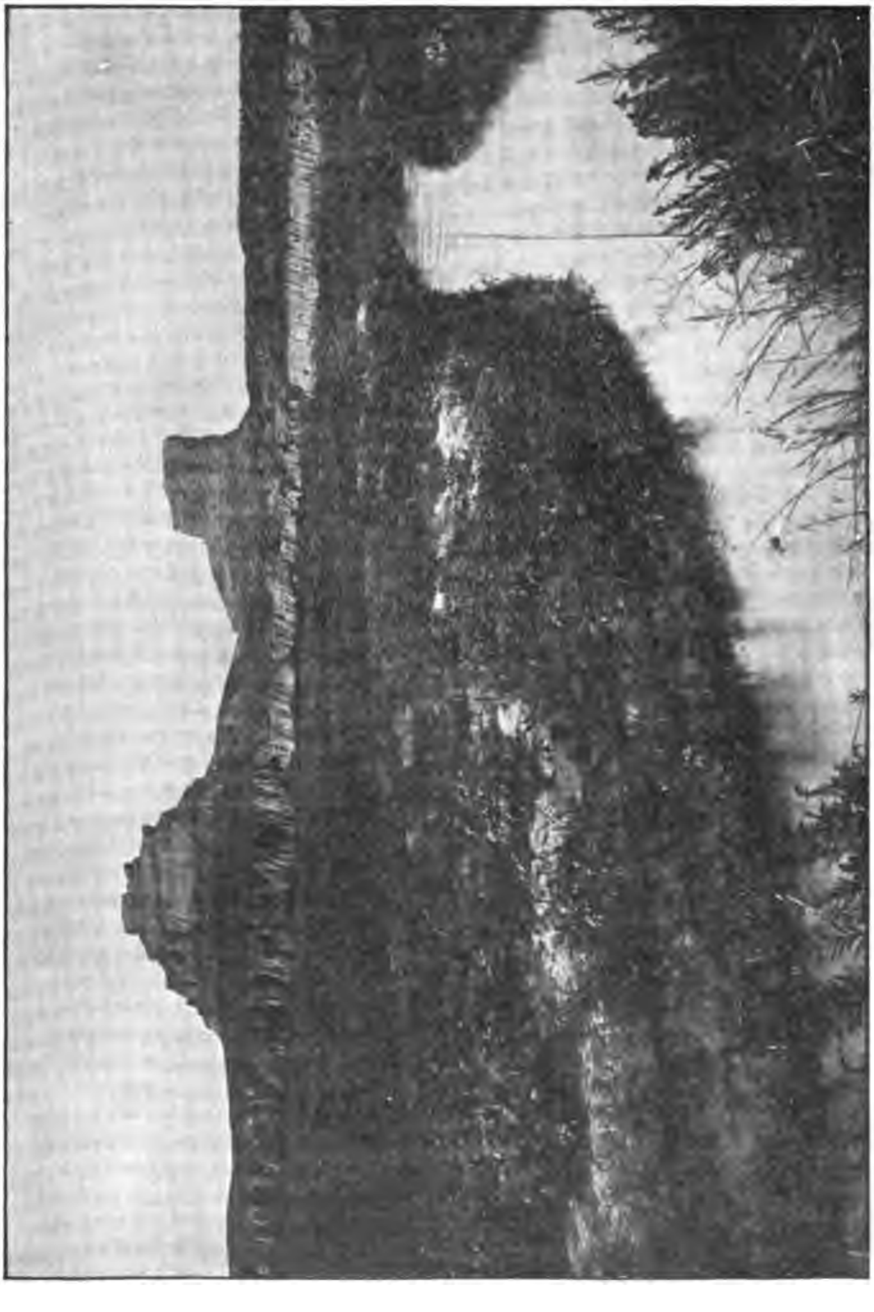


Fig. 11.—Courthouse (left) and Jail rock (right) looking north across Pumpkinseed creek, Cheyenne county, Neb., near its junction with the North Platte river. Photographed by N. H. Darton, United States Geological Survey.

particularly in the Loup system, nor by the strange way the Loups unite and run parallel to the Platte for one hundred or so miles.

PLATTE RIVER

Geographically this is our most important river. Its character varies in the different regions through which it flows. In Wyoming the North Platte has cut through mountain ranges, producing magnificent canyons between whose narrow walls it flows as a torrential stream capable of transporting great loads of rock waste. In the high table lands of western Nebraska, it has eroded a valley ten to fifteen miles wide and seven hundred or more feet deep. The valley floor, representing sediment deposited in a former greater valley, is bordered by numerous large canyons and many forms of buttes. Bordering terraces tell of the river's former greater size when it flowed as a much wider stream and at a higher level. In the upper terrace are found coarse pebble and cobble stones which were carried by a deep and powerful stream. In succeeding terraces materials grow finer and finer, and the channel narrows until we come to the river as it exists to-day, with a flood plain one to four miles wide. Here land is irrigated by some of the largest ditches to be found in the state.

The valley narrows in Deuel and Keith counties and widens again in the eastern part of Lincoln county. From this point to near Ashland, in Saunders county, the Platte is broad and shallow, heavily loaded, and flows at places as a network of interlacing streams among innumerable sandbars and islands, some of which are several miles in length. The river bed lies on a broad flood-plain, some 300 feet thick, and 200 to 300 feet above the Republican to the south. The valley floor is bordered by gradual slopes, hills, and, at some places, bluffs, between and in which occur ravines and small canyons.

At a number of points the river could be drained southward. It is not entirely visionary, therefore, to contemplate

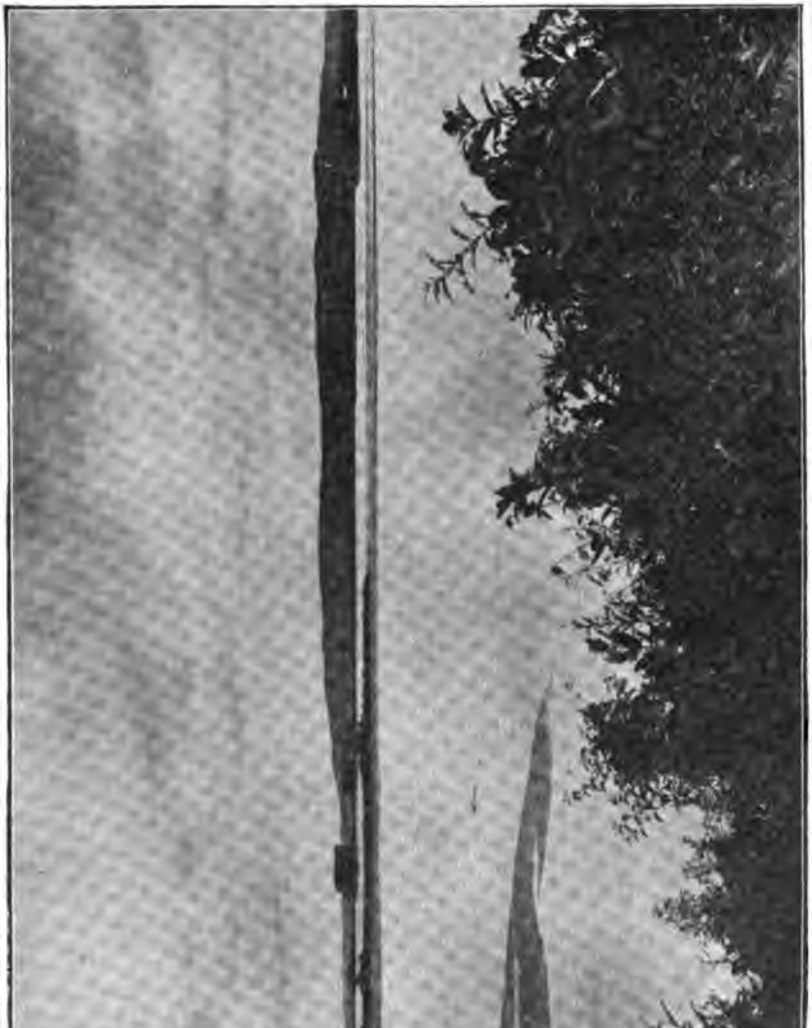


Fig. 12.—The Platte river near Ashland, Neb., showing stream deposits. Photographed by N. H. Darton, United States Geological Survey.

the irrigation of counties to the south by means of water from the Platte. However, the cost would be great and probably prohibitory, it being necessary to tunnel ten or twelve miles.

In the eastern part of the state, just below Ashland and where the river strikes the more resistant coal measure rocks, its valley rapidly narrows. The flood plain averages about one mile in width. This narrow course, in which

Fig. 13.—A view down the North Platte river from the Wyoming-Nebraska line, showing islands of sand.—After Darton.

valuable clays and limestones are exposed in bluffs 100 to 200 feet high, continues to the Missouri. While the Platte dries up at times throughout most of its course in the state, it must not be forgotten that the underflow in sands during dry weather far exceeds in volume that of the stream proper.

During the early spring freshets it presents the appearance of a mighty river, especially when its current is obstructed by great ice jams. At such times the valley is flooded, buildings are swept away, and new channels often

formed. Banks, sand bars, forested islands, railroad bridges, and masonry give way before it.

At places the wind has blown exposed sands into dunes, forming small outlying sandhill areas. Tributaries from the south are small and few in number. The Loups and the Elkhorn, to the north, are quite important rivers. The South Platte, on account of its limited supply of water and short course in the state, is of much less economic importance than the North Platte, yet many rich alfalfa and hay ranches are located along its valley.

LOUP RIVERS

These waterways as a system constitute the most important tributaries of the Platte. Three trunk streams unite in a strange way and run parallel with the latter for about 100 miles. Formerly each river flowed as an uninterrupted stream in a southeasterly direction and emptied into the Platte as a separate stream. Later, the stronger Platte, while slowly building up a bed some three hundred feet thick, obstructed the flow in the Loups by throwing sandbars across their mouths, and thus forced them to shift their courses eastward or down the Platte valley to find a new and united outlet over the steadily rising barrier of sand.

The Loups head in the imperfect drainage of the sandhills, where they are fed by numerous springs, and flow through the loess and earlier rock formations, draining an area of perhaps 20,000 square miles. Pasture and hay lands are found in the hills, while farther down the valleys much hay, wheat, and corn is produced. Alfalfa is coming to be an important crop.

ELKHORN RIVER

The Elkhorn, famous for its hay land, which meanders so erratically through its broad valley, traveling three miles or more in making one mile of actual advance, joins its alluvial valley with that of the Platte after making a sinuous journey of three hundred miles in the state, and is the second most important tributary of the Platte.

Historically, the Platte and its tributaries bear a close relation to the settlement of the state, which naturally progressed along the alluvial valleys.

MISSOURI RIVER

The Missouri river exposes some four hundred miles of river front in Nebraska, and might be a navigable stream but for its ever-changing current, which shifts its sandbars so often and so easily as to leave no regular channel. In the early days this was the highway for reaching Nebraska, and determined the rapid settlement of the eastern counties. Though discharging a large volume of water, it flows through that portion of the state where irrigation is not so necessary, so little of its water is diverted for agriculture, and little use seems to be made of it for the generation of power, its chief economic uses being to supply Sioux City, Omaha, and other places with water, and to transport small boats loaded with grain and stock. But let it be remembered that this river has controlled the development of some of our most important natural resources, for the exposure of valuable clays and building stones is due to the action of the Missouri and its tributaries. Had they not been laid bare in this way, it would not be profitable to quarry much of our rock, nor to work many good exposures of clay.

At Vermilion, S. D., its alluvial plain with an altitude of 1,140 feet is only 330 feet above the mouth of the Nemaha, in southeastern Nebraska. It has cut into different rock beds, forming bluffs 100 to 200 feet high on which there is a considerable growth of trees and underbrush; and many cottonwood groves are scattered along the valley floor, affording lumber and fuel. Large crops of hay are produced in the region of Blair.

WHITE RIVER VALLEY AND HAT CREEK BASIN

Probably the most striking physiographic feature in Nebraska is Pine Ridge. Just beyond and in the north face of this ridge or escarpment, White river and the tributaries

of Hat creek are carving out typical Bad Land forms. Hat Creek basin is in the extreme northwestern part of the state. The outer portion of the basin consists of deep canyons with steep walls. In the central parts are low hills which slope gently to the north. The tributaries are dry most of the year. Dams constructed in canyons afford water for cattle and irrigation. In 1897 nearly 2,000 acres were under ditch. The ponds fill rapidly with waste and prevent effective irrigation.

White river farther east, with a larger stream, affords plenty of water for stock and is used more extensively for irrigation. It rises in Pine Ridge at an altitude of about 4,800 feet and flows to the northeast with a gradient of fifty-five feet per mile, giving a fall of 1,100 feet for the first twenty miles. It becomes quite an important river near the Dakota line and remains an open stream during the winter. On account of the steep gradient and dry climate, very little plant growth survives on the slopes.

NIOBRARA RIVER

Rising in the high table lands just across the line in Wyoming, this swift stream flows in an easterly direction across northern Nebraska and joins the Missouri in Knox county. Throughout most of its length, except near the mouth, the valley is narrow and relatively deep in comparison with the width. The narrow flood plain in the western part of the state lies 400 to 500 feet below the crest of Pine Ridge and 400 feet above the North Platte river. The bordering bluffs or walls are modified by tributary canyons from which issue spring-fed streams. In the main valley and tributaries in the region of Valentine quite a thick growth of pines and deciduous trees is found. Also the bordering table lands are modified by sandhills.

A contemplated dam near the mouth of the Minichaduza creek would give great water power. Small areas of land are irrigated along the upper and middle courses of the

river. Near the Missouri the stream is shallow and spreads out among numerous sandbars.

LODGE POLE CREEK

This stream enters Nebraska from the Wyoming line and flows in an easterly direction about midway between the North and South Platte, joining the latter near Julesburg, Col. It has cut a valley some three hundred feet deep into the table land. The valley floor, one-half to two miles wide and bordered by rather steep slopes, has an elevation of 5,000

Fig. 14.—Bluff of carboniferous limestone exposed along the Nemaha river at Rulo, Neb.

feet at the Wyoming line, and an average slope to the east of about seventeen feet to the mile. The stream carries a limited supply of water, most of which is diverted for irrigation purposes. A strong underflow comes to the surface at various places as springs. By August most of the bed is

dry. The country between the bordering hills and canyons of this creek and the Plattes is, for the most part, a level table land cut into by an occasional canyon.

REPUBLICAN RIVER

The Republican river rises in the plains of Colorado and flows about 100 miles in that state before entering our own, in which it travels in a fine valley before turning south into Kansas. This is counted one of the important valleys of the state, and irrigation and alfalfa farming are said to be enhancing its reputation. In places the river has exposed clays and building stones of economic importance.

Fig. 15.—The Blue river and dam at Milford, Seward county, Neb.

BLUE RIVERS

Intermittent tributaries of the Blue rivers head at various places in the level loess plains near the Platte. The two

main streams flow southeastward, joining in Kansas. The valleys vary much in width and character at different places, depending on the rock beds over which they flow. At Fairbury, the Little Blue has cut through Benton limestone, glacial sands, and gravel, and into the Dakota sandstone, exposing limestone, clays, and sands of economic importance. Near Endicott, the Dakota sandstone with a covering of glacial boulders stands high above the surrounding country. In the region of Fairbury and Endicott, beds of tributary streams are covered with residual sand. The Big Blue has worn through flint beds of the Permian at Blue Springs and Wymore. The flinty limestone erodes slowly, producing rock terraces. The flint is crushed and used for ballast, while the limestone is used for building purposes.

These rivers afford good water power. They are among the most beautiful streams in the state and are frequently visited by camping and fishing parties.

SALT CREEK

The waters of this stream contain salt, hence the name. The main tributaries flow in the direction of the basin at Lincoln and join Salt creek proper, which flows through a broad valley in a northeasterly direction to the Platte. The bordering slopes and drift hills are covered by loess. Limestone exposed by this stream and used for building purposes is quarried at Roca, twelve miles south of Lincoln, and many bricks are made from its clay near Lincoln.

Many of the smaller streams show periodic fluctuation of water independent of rainfall, springs, pools, and streams which have dried up gradually reappearing in the fall and winter months, whether it rains or not, and the people account for the phenomenon on the ground of evaporation; that is to say, the water lost to evaporation increases in warm weather, when the streams disappear, and decreases in cold weather when they reappear. Evaporation averages four and one-half feet for the state, or, expressed more exactly, is three feet in eastern Nebraska, four and one-half in central, and six in western Nebraska.

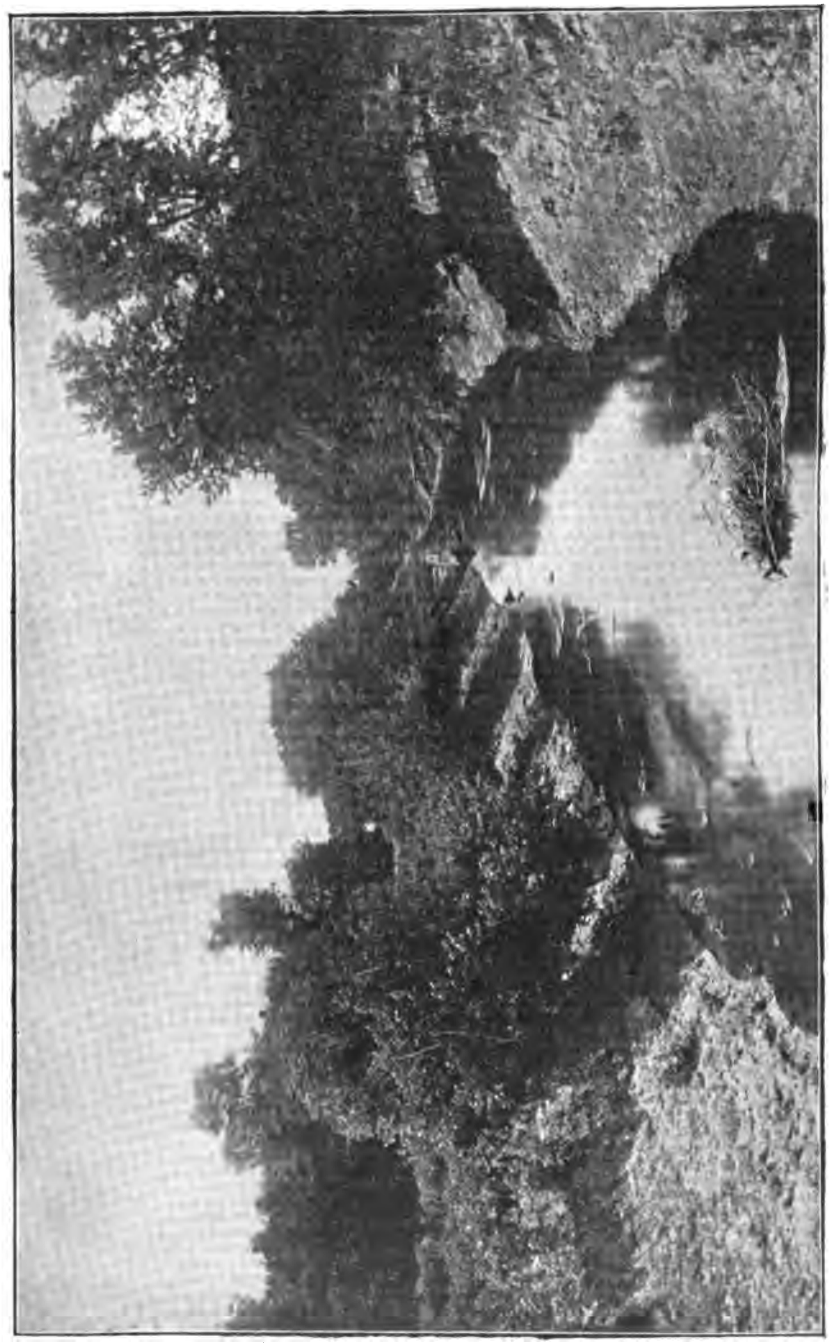


Fig. 16.—Recent valley deposits along Salt creek, Lancaster county, Neb. Photographed by N. H. Darton, United States Geological Survey.

WATERFALLS

Even our own citizens are poorly informed about the beauty and diversity of Nebraska scenery, and many are unaware that rapids and waterfalls exist. When seeking change of scene and rest, our citizens hurry out of the state, leaving behind them oftentimes more attractiveness and allurements to health than they find elsewhere. Many portions of Nebraska furnish features attractive enough for summer resorts and pleasure grounds. This is particularly the case along the F., E. & M. V. railroad from Long Pine and Valentine westward to Crawford, Harrison, and Fort Robinson in Sioux county, and along the B. & M. railroad northward from Crawford, especially in the region about Adelia, and the canyons of Pine Ridge.

People are praising the attractions of neighboring states, leaving ours unmentioned, unknown, and unvisited. Pleasure grounds and summer resorts should be counted natural resources, just as worthy as any others, to be properly developed and used for the pleasure and health of some, and for the profit of others. In many states the summer resort is a source of great profit to many people, and of great pleasure and rest to others, and it seems entirely possible to look forward to the time when comfortable hotels and summer cottages may be built in attractive places for those who need an outing, and who now spend their money outside of our state instead of in it.

Possibly the time may not be at hand for the development of these places of attraction, but it is an economic feature of the subject worth having in mind, and seems sure to be a reality, especially along the Fremont line of road, where the water is clear and plentiful, and the rocks high. Here are the finest springs of the state, and the greatest number of lakes and waterfalls. There are some peculiarly attractive spots around Valentine, in the region of the best waterfalls in the state. The scenery is bold and well forested with evergreens and deciduous trees, and well watered, and the

surroundings are altogether attractive. The trouble now is that the lakes and waterfalls are so inaccessible. To visit Snake falls, the finest in the state, it is necessary to drive twenty or thirty miles. Here the Snake river, which is some seventy-five feet wide, carrying three to four feet of fine, clear water, makes a vertical plunge of about twenty-two and one-half feet, with a projection of ten feet. It is all the

Fig. 17.—Distant view of Snake falls, Cherry county, Neb. Plunge, 22 feet; width, 50 to 75 feet. Exposures of Arikaree sand rock are seen in the canyon walls and sandhills in the distance.—Morrill Geological Expedition, 1900.

more beautiful and attractive because so unexpected. Above the falls proper there are a number of cascades and rapids, and lesser falls ranging in height from two to five or six feet. Snake falls has cut a sharp canyon in the Arikaree formation, and is well timbered with pines and underbrush, while in the streams of this vicinity the water is pure enough for trout.

The tributaries of these streams have numerous rapids and falls, the boldest of which is probably that known as Schlegel

falls. Here a white sheet of water, forty to fifty feet wide, shut in by walls of pine-covered Arikaree sandstone, pours over a twelve-foot ledge, constituting a very interesting waterfall, while a series of cascades above adds to its beauty and attractiveness.

In the interior of the state the North Loup drops twelve feet over the same formation, making the second largest waterfall in Nebraska.

Fig. 18 —Schlegel rapids and falls southwest of Valentine, Cherry county, Neb., in the Arikaree formation. Plunge about 12 feet, width about 50 feet.

The loftiest fall is named Arikaree falls, on the ranch of Hunney Smith, some twelve miles east of Valentine, Neb. This makes a vertical plunge of about eighty-five feet, and a second leap of about fifteen feet. Though small, it is a beautiful ribbon of water. Rising in innumerable springs a few hundred yards above, it flows over a ledge of Arikaree sand and empties into the Niobrara river. The existence of these falls is due to the cutting of the Niobrara and its tributaries, whereby high walls are left standing, almost vertically, for

one hundred to three hundred or more feet, and over these the water drops with fine effect. A mile away may be seen Wonder falls, a veil of water pouring down over a nearly vertical cliff of Brule clay.

Doubtless other falls exist, but the ones described and figured here are those visited by the writer, and others, if they occur, will be made known in succeeding reports.

Fig. 19.—Falls of the North Loup. Plunge about 12 feet, width 40 to 50.

LAKES

Few are aware of the number of lakes of which Nebraska boasts. There are about one hundred surveyed lakes, and they are said to cover about eleven hundred acres. Many of these are in the sandhill region, and it may be that they are due in whole or in part to drainage which has been embarrassed by sandhills. Unfortunately, some of these lakes are apparently filling at a rapid rate, so we can look forward to their ultimate obliteration. Watt's lake, as an example, has suffered a contraction of about three-quarters of its area in ten years. Sand is the chief agent; this is carried by the

Fig. 20.—Arikaree Falls, on the Hunny Smith ranch, some ten miles east of Valentine, Neb., fed by sandhill springs and leaping over a wall of Arikaree sand rock. First plunge, 85 feet; second, about 15 feet. These are the loftiest falls in the state.—Morrill Geological Expedition, 1900.

wind and deposited in the water. Around the margin of the lake certain plants and grasses find conditions favorable for growth; within this may be found concentric circles of other plants of a more aquatic nature, which add to the work of filling and obliterating the lake.

Fig. 21.—Watts lake, Cherry county, Neb.

The lake region occupies the central portion of the sandhills and, beginning in Brown and Rock counties, reaches a maximum in Cherry and Sheridan counties, and extends south into Grant and Hooker counties. A cluster of small lakes occurs in Phelps and Kearney counties south of the Platte.

The largest group of lakes is found in Cherry county, south of Valentine, extending to the southwest some twenty-five to thirty miles, and including fifty or more lakes. Among the largest and best known of these may be mentioned Pelican lake, Wood lake, Dad's lake, Marsh lake, Clear lake, Red-deer lake, Watt's lake, and so forth.

Some thirty-five miles farther west occurs another lake region near the western boundary of Cherry county at the head of the North Loup river. There are thirty or forty lakes worthy of mention in this group.

Southern Sheridan county has five or six townships well dotted over with lakelets, only a few of them being large. At many points in Fillmore, Adams, York, and other counties on the level loess plains occur the weather ponds and swamps. Few of them contain enough water to be called lakes. They are a hindrance to farming and result from imperfect drainage.

South of the Platte in Kearney and Phelps counties there are numerous lakes, and along the river courses, particularly along the Missouri, occur many cut-off lakes, resulting from the excessive meandering of the river. An attempt is made to represent some of these lakes and cut-offs in the accompanying maps, but the bulk of them are too small to show on this scale. Some of the lagoon lakes have been the occasion of interesting litigation. For instance, the boundary between Iowa and Nebraska is the axis of the Missouri river. However, since the stream shifts so rapidly that it swings out of its course a mile or two in a season, it is plain that portions of Nebraska are going to be left in Iowa, and portions of Iowa included in Nebraska. At Florence lake and Cut-off lake, just north of Omaha, a portion of Iowa was left in Nebraska when the Missouri cut a channel across the neck of a great meander, and it has been the decision of the supreme court that this land shall still continue as a part and property of the state of Iowa, subject to its laws; though, in fact, as the river now stands, it is distinctly in Nebraska. In a similar manner a township of land belonging to Nebraska is entirely east of the Missouri river. It happens that government boats in improving the Missouri were compelled to travel miles around a great curve or oxbow in "riprapping" the banks to protect the railroad from washing away. They found it possible to shorten the journey by cutting a channel across the narrow neck of the bow.

This channel the river accepted at once as a shorter and better course, leaving a large tract of land, ever since known as Hog Thief island, stranded in Iowa.

These lagoon lakes are usually quickly reclaimed to cultivation, being particularly rich, filled as they are with alluvium from the neighboring hillsides, and with wind-borne sand and aquatic plants.

The lakes of the sandhills are important economically in that they afford a remote and safe breeding ground for large numbers of water birds, and are stocked with bass and other food fish, and supply water for the herds of the region—cattle raising being almost the exclusive industry of Cherry and adjacent counties. The sandhills are on a generous plan here, rising ridge above ridge like mountains, so that they catch and hold the rainfall and dole it out to the lakes, springs, and streams of the region.

The season of 1891 was one of exceptional rainfall, and these lakes were at their best. During the protracted drouth from 1892 to 1895, they were reported as being seriously affected. Since that time they have reached their normal condition, even passing it during the phenomenally wet year of 1902, for the rainfall of that year exceeded all records, being over forty inches.

Innumerable artificial lakes and ponds are being constructed yearly, and in this method of storing water lies possibilities of economic importance. Few states can lend themselves more readily to the impounding of water for stock and irrigation than our own, especially in the butte region, where it is possible by simple and inexpensive dams to set back and impound large volumes of water. In some regions it is the practice to protect the cattle and sheep industry by damming draws and streams at certain intervals to insure a constant and ample water supply for the great herds.

The cattle, sheep, and irrigation industries may greatly benefit by the multiplication of artificial lakes, ponds, and pools. But there are other industries to be considered as

Fig. 22.—Artificial ponds of the Moulton Ice Co., Lincoln, Neb., supplied with water by two turbine windmills. Stocked with carp and bass. Illustrates how an unsightly spot may be rendered sightly by artificial ponds.

well. The ice harvest is an important industry, and in many places is dependent on the artificial pond. Perhaps the best known and largest artificial pond or lake is that on the estate of Dr. George L. Miller at Deerfield, a suburb of Omaha. This lake covers from thirty to forty acres, is well stocked with desirable food fish, and furnishes ice for one of the largest packing houses of Omaha. It is fed by a small stream and springs, but mainly by a ten-inch artesian well.

In the valley of the Minichaduza creek just north of Valentine is one of the most beautiful artificial lakes in the state. It furnishes power, water, fishing, skating, and boating. The water is clear, deep, and of spring origin. The steep valley slopes are well covered with pines and deciduous trees.

Salt lake or Burlington beach, just west of Lincoln, was at one time a well-kept summer resort, furnishing boating, sailing, bathing, skating, and duck-shooting in season. This in a certain sense is a natural salt lake, but in another sense is artificial, inasmuch as its extent has been greatly increased by a dam. See fig. 23.

SPRINGS

Springs are so seldom observed along the ordinary routes of travel that one is inclined to imagine none exist. To the contrary, there are many springs in the state, some of them of considerable importance. Furthermore, they are put to a great variety of economic uses. The weaker springs are turned to account in filling the water trough and milk house, while some, by the aid of the hydraulic ram, deliver water to the house and stockyard. Some of our springs are so strong that they are spoken of as artesian springs, and if their waters are confined in a tube, they will rise two or three feet, showing they come to the surface under a good head.

In certain regions, noticeably the sandhills, there are so many springs that streams start from them, and are fed by them along their courses until they become good streams of water. At Fort Niobrara, five or six miles east of Valentine,

Fig. 23.—Burlington Beach, near Lincoln, Neb. Illustrating the utilization of the saline water of the salt basin.

Fig. 24.—Springs from Dakota sandstone along the Missouri river near the mouth of the Platte river, Sarpy county, Neb.—Darton.

numerous springs in the sand unite to form a stream which, within two hundred yards, is large enough to supply the inmates of the fort, numbering about one thousand persons, and the stock, lawn, etc. Besides, there is a surplus sufficient to supply water for an artificial lake, large enough for boating, bathing, and fish culture.

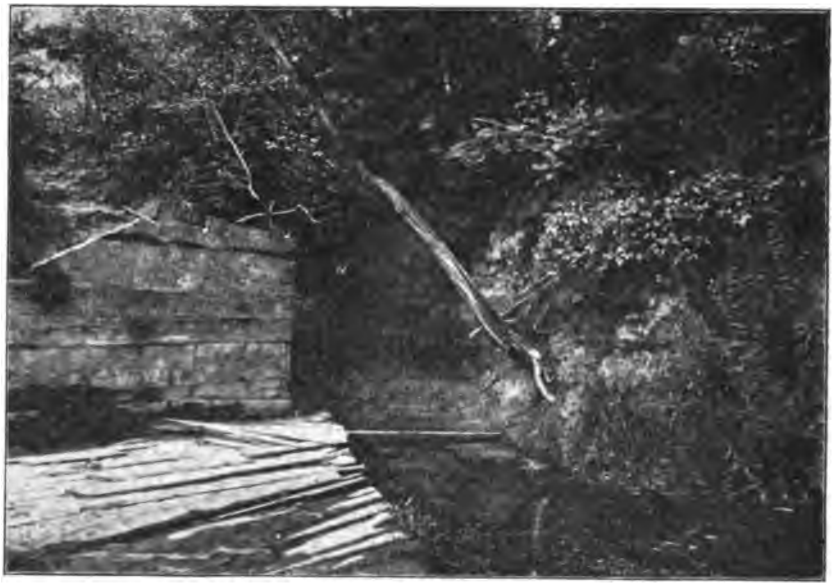


Fig. 25.—Big spring and floating platform, Chautauqua grounds, Long Pine, Neb.

In a similar manner water boils out of the sands at the head of Smith canyon, some ten miles farther east, and within two hundred yards becomes an interesting little stream which feeds Arikaree falls, already described as the loftiest in the state. These springs are trampled by fifteen hundred cattle, and yet the tendency of the water to well up to the surface and escape is so strong that the sand boils in hundreds of spots over several acres.

In several localities, especially in Rock county, near Kirkwood, there are strong springs that boil up with such force

that, if the water be confined by placing several joints of old stove pipe in the throat of the spring, the pressure is sufficient to lift the water several feet above the surface. Springs of this kind are numerous, particularly in this vicinity. Since the water rises under pressure, the local name "artesian spring" is applicable. Similar springs in Johnson county

Fig. 26.—Long Pine canyon at Seven Springs. These seven strong springs emerging at the base of Arikaree sand rock feed the stream shown in the foreground. The high bridge spanning the canyon is that of the Fremont, Elkhorn & Missouri Valley railroad. Water for the railroad, stock yards, and town of Long Pine is supplied by these springs, the pumping plant being back of the central pier of the bridge.—Morrill Geological Expedition, 1900.

are called "mound springs," because the water in the center appears to boil up, and is higher than that of the edge. This boiling occasionally gives them the name "kettle springs." Such springs near Sterling are thirty feet across, and the overflow is reported as three feet wide and two feet deep.

Particularly strong and interesting springs occur at Long Pine, and are well known because the Chautauqua grounds

are situated picturesquely in the canyon, near some of the largest of the springs. Farther down the stream is a spot known as Seven springs. These seven strong springs supply more water than is needed for the town of Long Pine, and for the engines and stockyards of the F., E. & M. V. railroad, and the water which flows away makes a stream six feet wide and two to three feet deep.

Fig. 27.—State Fisheries building on the north bank of the Platte at South Bend, Neb., supplied with water from strong springs at the base of the Dakota sand rock.—Morrill Geological Expedition, 1900.

An admirably interesting and important use to which some of our springs are put may be found at the State Fisheries, at South Bend. The location of the hatcheries at this point is said to be due to the fine, clear springs found there. The springs rise some fifteen feet above the level of the Fisheries building, hence the water flows of its own accord through each of the artificial ponds, through the hatcheries below, and into the large fish ponds beyond. The brown, rusty sandstone, which belongs to the Dakota Cretaceous, outcrops here, and the springs occur along the line of con-

tact between this and the underlying impermeable limestone and clays of the Carboniferous, where the water escapes freely. Should occasion arise it seems possible to greatly increase the output of these springs by opening them so as to expose broader surfaces for seepage. The present flow is described by saying it fills an eight-inch pipe, having a fall of one foot in ten. A hydraulic ram connected with these springs supplies water for the house and barns of the fish commissioner, situated high above on the summit of the bluff.

As compared with those of New England, we have few springs, still every county has some, ranging in the amount of discharge from a few gallons an hour to many barrels a minute, and hence capable of supplying some of our towns with spring water.

Numerous saline springs supply the salt basin west of Lincoln with water, by the evaporation of which salt was profitably obtained until the salt mines of Kansas were opened. Many of our springs, like our marshes and small streams, exhibit tendencies to disappear and to reappear without any directly assignable cause, a phenomenon which has often caused considerable public comment. This matter is briefly considered under Fluctuation of Water Level.

WELLS OF NEBRASKA

Closely akin to the springs of the state are the wells, which may be considered as artificial springs.

Wells are of the utmost consequence to a commonwealth, and while space will not admit of a discussion of the subject at this time, nevertheless certain features should be briefly mentioned. The depth to water, the constancy of the supply, and the quantity and quality obtainable concern every citizen. It is said that that country is assuredly healthful which boasts of pure air and pure water; either of these, if contaminated, is apt to prove detrimental to health.

Fortunately, the well water of our state, though hard as

a rule, is pure and free from contamination, and found at little more than ordinary depth.

It may be stated at the outset that as a state we are provided with the best of water by ordinary wells of average depth. Some of these toward the northern central part yield soft water, those of southeastern, southern, and western Nebraska yield hard water, similar to that found in the limestone regions of other states. Some wells yield iron, sulphur, and mineral water, and a few are astringent from the presence of free sulphuric acid in the water.

In certain portions of the Cretaceous shale regions, wells, if they yield water at all, yield a very alkaline sort, unfit for the use of animals, plants, or even for boiler purposes. Such regions are exceptional and of restricted area.

In the southeastern, or Carboniferous counties, wells and certain springs are distinctly saline, often too salt for use. It is frequently a question how to avoid striking saline water in digging wells, and farmers often report that great care must be exercised not to dig too deep, or, after using a while, the water will become salt. The same trouble is sometimes experienced in digging for town supply, as at the F street and South street wells in Lincoln, where they had good water at the start. In order to increase the supply they dug deeper, and in spite of their best contrivances the city could not shut out the salt water, and the pumping stations were abandoned.

In several counties salt water is almost a certainty at a hundred to one hundred and fifty feet, and thence downward the water continues salt. In a few places in the southeastern counties where the Carboniferous rock comes close to the surface, wells yielding enough water for ordinary use are hard to find. However, all of these are to be viewed as exceptions, and any prospective citizen can depend on finding water throughout the state.

In the butte region, where the table lands are from one hundred to six hundred feet above the general level, wells are often deep, varying from one hundred to three or four hundred feet, the water obtained being the very best.

The average well in Nebraska is about thirty to thirty-five feet deep, yet there are thousands of wells, especially in the valleys, not over fifteen to twenty feet deep.

ARTESIAN WELLS

Ground water is almost universal and is the source of the supply of common wells. In addition to this there is the extraordinary subterranean water which supplies artesian wells. In the common house well the water seeps in and

Fig. 28.—Artesian well at Beaver Crossing, Seward county, Neb. Utilization of artesian water for the beautifying of parks.

stands quietly at a certain level. In the artesian well it comes in under pressure. This is the only essential difference between the two. The artesian wells in Artois, France, from which the name "artesian" is derived, were the first dug and observed. These were spouting wells from deep sources; hence the term artesian presupposes in the public mind a spouting well from deep-seated sources.

This early conception, however, is not the true one. Many artesian wells are shallow, not over sixty to eighty feet in depth, but yet are true artesian wells. Many throw fine streams from a few inches to several feet high, and are unquestionably artesian wells; but a short distance away at a higher level the same water will rise in the well under the same pressure and is likewise artesian, even though the head is not sufficient to force it above the surface. The one is an active, positive, flowing artesian well; the other a negative, passive, or standing artesian well.

Fig. 29.—Well on farm of T. M. Ferguson at Beaver Crossing, Neb. Depth to artesian water, 80 to 90 feet. Height of pipe, 13 feet; diameter, 6 inches. Mr. Ferguson irrigates 112 acres from nine such wells, which cost $900.

In Johnson and Seward counties the shallow artesian wells are beautifully represented. They occur in valleys where the surface has been washed away and lowered, thus enabling the pressure or "head" to force the water above the surface ten to twelve feet. On this level, flowing wells are everywhere

to be found, which are already put to many economic uses, and farms which are models of their kind draw their water for irrigation from this source with no cost. These are positive or flowing artesian wells. On farms a few feet higher precisely the same water is struck. It rises to the surface, but can not flow over it.

It is universal experience that rocks, some soft and porous, some dense, are found in the state arranged in horizontal beds. The denser layer will constitute the impervious jacket around the more porous layers. The layers which are deeply buried here, and but inappreciably tipped, may come to the surface elsewhere and form a catchment basin, perhaps at a point far distant, as is the case presumably with the deeper wells found along the northern and northeastern boundary of the state.

The artesian wells, as far as reported, fall into four rather natural groups, as follows: The deep wells of the Carboniferous, such as those at Beatrice, Lincoln, and Omaha, varying from 556 to 2,463 feet; the artesian wells of the northeastern counties in the Dakota sandstone, 300 to 600 feet deep, being a continuation into Nebraska of the South Dakota artesian basin; the shallow wells in glacial sands and clays, such as those at Cook and elsewhere; and other shallow wells not in the drift, such as those in Holt and Rock counties.

There are local artesian basins in the state which are more easily understood than the deep wells. There are small basins of ten to fifteen square miles each in the valleys of streams, depressed noticeably below the general level of the surrounding hills. Within this circumscribed area, wherever the impervious roofing or encasement of clay is pierced—the depth varying from forty to one hundred or more feet—there comes a strong and constant flow. Such wells are too shallow to draw their water supply from a distance.

It is at once apparent that the artesian supply for these local basins is drawn from beds of alternating gravel, sand, and clay, and that it is rather limited and local, though none

the less important, as has been sufficiently demonstrated by its multifarious uses. One farm at Cook, Johnson county, in the midst of flowing wells, has failed, and always must fail, to furnish artesian water, and there is apparently nothing anomalous in the case. The farm is over what is called a "clay island." All the wells dug on this farm penetrate clay only, and, of course, one can not hope to strike artesian water there.

These local artesian wells are already turned to admirable account in supplying ponds for fish culture, fountains for school yards and parks, and water for domestic use and for irrigation. The last-named use is destined to become of considerable economic importance. Some farmers have already from eight to ten five-inch wells per farm with which to irrigate over one hundred acres each. The number who have tapped the subterranean reservoir and allowed the imprisoned water to escape and to flow away aimlessly and uselessly far exceeds those who have put it to intelligent use. There is enough artesian water wasted thus to irrigate whole farms. What renders this matter all the more deplorable is the obstinacy of many people in insisting that the supply can not be exhausted. This view is wholly fallacious, and if persisted in may result in damaging or destroying altogether an important resource. Every well dug must diminish the head or pressure that much, whether the amount is perceptible or not. Unrestricted abuse of these water privileges can but result disastrously here as elsewhere. All this water should be most conscientiously used and conserved.

FROM THE NEBRASKA IRRIGATION LAWS, 1897

Sec. 16. (WASTING MUTUAL ARTESIAN WATER.) That it shall be unlawful for any owner or owners, lessee or lessees, occupier or occupiers, foreman or superintendent of any farm, town lot, or other real estate in the state of Nebraska, where artesian water has been found or may be found here-

after, to allow the water from wells, or other borings or drillings, on any farm, town lot, or other real estate in Nebraska, to flow out and run to waste in any manner to exceed what will flow or run through a pipe one-half of one inch in diameter, except where the water is first used for irrigation, or to create power for milling or other mechanical purposes. (1897, chap. 84, sec. 1.)

Fig. 30.—Artesian well on the estate of Dr. George L. Miller, 7 miles west of Omaha, Neb., supplying water for a 30-acre lake, concealed from view by trees. Depth, 1,430 feet; 10-inch pipe; pressure, 15 pounds to the square inch; discharge, 1,100,000 gallons a day.

Sec. 17. (Same—Penalty.) Any person or persons who own, occupy, or have control of any farm, town lot, or other real estate in the state of Nebraska, who fail or refuse to close or shut off any wastage of artesian water to the amount that this act allows on any farm, town lot, or other real estate which they own, occupy, or have control of, after being notified in writing by any person having the benefit of said

mutual artesian water supply, within forty-eight (48) hours after such notification, shall be subject to arrest, and upon conviction be fined in any sum not less than ten (10) dollars nor more than twenty-five (25) dollars, and pay the costs of such arrest and prosecution for each offense; and if such wastage be not abated within twenty-four hours after such arrest and conviction, it shall be deemed a second offense against the provisions of this act, and be subject to the same fine as for the first offense. And every like offense or neglect of each twenty-four hours thereafter shall be deemed and considered an additional offense against the provisions of this act.

Fig. 31.—Portion of a 30-acre lake on the estate of Dr. George L. Miller, at Deerfield, 7-miles west of Omaha, fed by an artesian well. The Miller residence and grounds seen beyond. This lake is used for boating, for fish culture, and for ice harvest. It supplies ice for one of the large packing companies of South Omaha.

Sec. 18. (SAME—PROSECUTIONS.) All prosecutions under the provisions of this act shall be brought by any person in the name of the people of the state of Nebraska against any person or persons violating any of the provisions of this

act, before any justice of the peace of the county in which such violation is alleged to have taken place, or before any court of competent jurisdiction.

Fig. 32. — Riverview Park artesian well, near Omaha, Neb. Depth, 1,060 feet; capacity, 114,427 gallons a day; 6-inch pipe; water but slightly saline; temperature, 62°; cost, $1,000. This well supplies annually to the park system of Omaha a volume of water which, at the lowest wholesale city water rate, would cost $5,000 a year, and illustrates the use of artesian water for the beautifying of parks. In addition to the fountain and stream a small lake is supplied by the well.

There are now so many artesian wells, and so many uses to which they are put, that a report on the subject must be deferred for the present. However, it will not do to omit a brief report of a few of the best known and most important. Probably the most important artesian well in the state is the test well at Lincoln. This well was sunk by a diamond drill to a depth of 2,463 feet and a core taken out, which is preserved for reference in the state museum. The state spent $20,000 in sinking this well for the purpose of determining whether coal, oil, or gas occurred in paying quantities. A

full account of this well may be found in the Sixth Biennial Report of the Commissioner of Public Lands and Buildings to the Governor of Nebraska, December 1, 1888, pp. 57--84. A section of this well may be found under the Carboniferous formation. Probably the best known well is that of Dr. Miller, at Deerfield, near Omaha, which is 1,430 feet deep, yields seventy gallons a minute, has a pressure of 15 pounds, and a

Fig. 33.—Industrial Scene at Niobrara, Knox county, Neb. A 60-barrel flour mill, electric light plant, and city water works run by an artesian well; depth, 656 feet, 8-inch pipe, pressure 95 pounds to the square inch, discharge 2,500 gallons a minute; throws a column of water 80 feet high; temperature 75°, cost $3,500. From an economic point of view this seems to be the most important artesian well known in the state. Important artesian power is obtainable in this region.

temperature of 62° and supplies a thirty-acre pond used for raising fish and for ice harvest. This is a very fine artesian well. There are many other wells at Omaha used for the beautification of public parks, etc., as may be seen in the table of wells, under Douglas county. The most consequential artesian well is that at Niobrara, Knox county. This

well, sunk to a depth of 656 feet, discharges a powerful stream through an 8-inch pipe. This is conducted against a four-foot Pelton wheel and drives a sixty-barrel flouring mill, electric light plant, and pumps water for the city supply. The flow is 2,500 gallons a minute under 95 pounds pressure, and it throws a stream 80 feet; temperature 75°. The writer's description of this well may be found in the *Scientific American*, vol. 85, no. 2, p. 21, July 13, 1901.

Fig. 34.—Artesian well in Holt county, 18 miles south of O'Neill, on the Fremont, Elkhorn & Missouri Valley railroad.

There are numerous valuable wells in this county. In certain spots in Brown and Holt counties artesian wells are often found so near the surface that cattle men and sheep men make a practice of carrying ten or a dozen feet of iron pipe, which is driven into the sand, and down through a clay layer and flowing water obtained. We have seen wells made in this way which have been flowing for the past two or three years.

TABLE OF ORDINARY WELLS AND ARTESIAN WELLS, ARRANGED BY COUNTIES.

LOCALITY	NAME	Depth	Diameter	Yield per minute in gallons	Height of water in feet	REMARKS
Adams						According to reports, ordinary wells average 106 ft.; average cost, $35.
Hastings	Test well	1350			1310	Salt water at 440 feet, cost $4500.
Antelope						Ordinary wells av. 126 ft., cost $49.
Neligh	T. H. Brenton	100			80	Hydr.; flwd several days, settled 20 ft.
Elgin						Several artesian wells reported.
Banner						Ordinary wells av'age 44 ft., cost $33.
Harrisburg	Deep well	800				No artesian wells reported.
Blaine						Wells average 51 ft., cost $41.
						No artesian wells reported.
Boone						Ordinary wells reported to be 159 ft., average cost $120.
Albion	Deep well	320				No artesian wells reported.
do	Test for coal	1700				Unsuccessful.
Box Butte						Wells average 166, cost $98.
Lawn	Deep well	247				No artesian wells reported.
Boyd						Wells average 20 to 25 feet.
Alford	G. L. Emmons	760	3	420	FLOWS	Cost $1000, used for irrigation
Butte	Wm. Kearville	760	3	100	do	Cost $2000, used for irrigation.
Lynch	Welna & Tomek	682	6		do	Good stream.
do	Davis farm	680	4		do	
Ft. Randall	Reservation well	700			do	Flows good stream but unfit for use.
Spencer	Cal. Moffet				do	Strong flow; used for irrigation.
Brown						Wells 50 to 60 feet; cost $30 to $40.
Ainsworth	City well	52				Yields 151,000 gals. every 24 hours. Well and plant cost $8000.
						No artesian wells reported.
Buffalo						Average of 50 wells 35 ft., cost $26. Deepest well 120 ft.
						No artesian wells reported.
Burt						Wells average 79 feet, cost $62.
Tekamah	City well	102	8	300	NO FLOW	This well cost $408, cost of pumping machinery $2000.
do	Two city wells	103	3.4		FLOWS	Flow too slow, pump attached.
do	A. E. Thompson	175			do	
Craig	Richard Nesbit	126			do	Ceased to flow and became a "whistling" well.
Butler						Wells average 64 feet, cost $59.
David City	Deep well	290				No artesian wells reported.
do	do	288				
Cass						Average of 81 wells 46 ft., cost $40.
Union	H. W. Lloyd	480	3		NO FLOW	Water at 30 ft., salt water at 470 ft., cost $725.
do	do	500	4		do	Salt water, cost $750.
Weeping W'r	City well	310			do	Cost $1000.
Cedar						
Aten	C. W. Sebring	397	2	20	FLOWS	Cost $100.
Bow Valley	Frank Arens	535	3	4	do	Flow has decreased, cost $200.
Hartington	Theo Beste	310	2	56	do	
do	do	225	2	50	do	Cost of the 3 Beste wells $60 to $125.
do	do	275	2	50	do	
St. Helena	David Nelson	333	2		FLOWS	Raises water 30 ft. Has 3 such wells, cost $80 each.
do	John Lammers	600	2		do	Has flowed 5 years, cost 500
do	J. Chamberlain	602	2	25	do	Cost $125.
St. James	Nels Anderson	400	2	50	do	Cost $400.
do	Martin Cullen	600	2		do	Cost $300. Flow decreasing.
do	Jas. Dawson	340	2		do	Cost $105.
do	L. E. Jones	300	2		do	Cost $70.
do	Peter Keegan	200	2		do	Cost $80.
do	H. E. McKenzie	448	2	50	do	
do	H. C. Cropping	481	2		do	Decreasing flow, cost $150.
do	Ernst Ferber	241	2		do	Decreasing flow, cost $75.
do	Jesse Griffith	280	2		do	Decreasing flow, cost $75.
						Artesian wells av. 387 ft., cost $143.
Coleridge C'y	City well	200			NO FLOW	Yields 125,000 gals. a day. Cost, including pump, $1400.
Chase						Wells average 143 feet, cost $62.
Champion	J. M. Bender	500	4		NO FLOW	Not artesian, cost $500.

TABLE OF ORDINARY WELLS AND ARTESIAN WELLS—*Continued*

LOCALITY	NAME	Depth	Diameter	Yield per minute in gallons	Height of water in feet	REMARKS
Cherry						36 to 170 ft. Eastern shallower, western deeper.
Cody	City well	280			NO FLOW	
Woodlake	C A. Johnson	100	4	1½	FLOWS	Cost $50.
Cheyenne						Wells average 176 ft., cost $118.
Sidney	Four wells	300			NO FLOW	No artesian wells reported.
		300			do	
		300			do	
		346			do	
Clay						Wells average 91 feet, cost $46.
Edgar	City well	165			NO FLOW	Well and pump cost $1000.
Colfax						Wells 10 to 40 feet.
Schuyler		285			NO FLOW	
Cuming						Wells average 50 to 60 ft., cost $62.
Wisner	J. E. Melcher	97	2	110	FLOWS	Cost $97.
Custer						Wells average 180 ft., cost $108.
Cliff	Deep well	485	3½-1½		NO FLOW	No artesian wells reported.
Dawes						Wells average 50 ft., cost $75.
Chadron	Deep well	400			NO FLOW	Yields no water.
do	do	1000			do	do
do	do	1800			do	do
Crawford	W. H. Fanning	82	6	4	FLOWS	Cost $60.
do	H. E. Grant	82	6	24	do	Sulphurous, cost $100.
do	Jos. Moseller	18				Strong flow, obstructed later by quicksand.
Dawson						Wells vary from 15 to 70 ft., on the tables from 120 to 390 ft.
Farnam	J. M. Tufts	390	3½		NO FLOW	No artesian wells. Cost $350
Dakota						Few reports. No artesian wells; one well 190 feet, no flow, but inexhaustible supply.
Deuel						Valley wells 10 to 45 feet, tables 50 to 336 feet.
Day	Hy. Moos	336	2		NO FLOW	No artesian wells. Cost $740.
Dixon						Wells average 30 to 40 ft.
Newcastle	T. J. Ryan	409		50	FLOWS	Steady flow, signs of decrease. Cost $1 a foot.
do	do	265		50	do	do
do	Dexter Rice	265	2		do	First flow at 160 ft. Cost $100.
Ponca	Geo. Matthison	484	3		NO FLOW	Flowed 3 weeks, settled 6 ft., unlimited supply.
do	F. P. Ryan	407	2	60	FLOWS	
Dodge						Wells average 60 feet, cost $52.
Ames	Sugar Factory					Flow reported at 235 ft.
Hooper	Henry Moeller	304	2	40	do	Cost $304.
Douglas						
Elkhorn		65			do	Cost $45.
Omaha	Clark and 16th st.	664		125	do	Raises water 52 ft., temperature 58°.
do	Grant smelter	1044	10-6	800	do	Raises water 65 ft., flow at 600 ft., and at 800 ft. 55°.
do	32d and O st	1800		Many	—70	Negative artesian.
do	Elmwood park	1880			—50	do
do	Hanscom park	1120		Many	—138	do
do	Riverview park	1065	4	600	FLOWS	Temperature 62o, salt.
do	Willow Springs, or Iler's	1700		Many	do	Lifts water 100 feet. Pressure 37 lbs. to square inch.
do	Exposition well	1115		30	do	Temperature 60°.
do	Seymour park	1303		500		Raises water 35 feet.
do	Pickard well	1383	10	70	FLOWS	Abandoned. Temperature 62o.
do	Krug brewery	1310		Many	—142	Negative artesian.
do	Power H. 19th st.	840				
do	Courtland Beach	998	6-5		FLOWS	Raises water 40 feet.
Dundy						Wells average 130 feet, cost $55.
Ough	Deep well	256			NO FLOW	No artesian wells.
Fillmore						Wells average 115 feet, cost $57.
Fairmont	Deep well	250			do	No artesian wells reported.
Franklin						Wells average 179 feet, cost $49. No artesian wells reported.
Frontier						Wells average 183 ft., cost $84. Blowing wells common.
Stockville	Deep well	310			do	No artes an wells.

TABLE OF ORDINARY WELLS AND ARTESIAN WELLS—*Continued*

LOCALITY	NAME	Depth	Diameter	Yield per minute in gallons	Height of water in feet	REMARKS
Furnas						Wells average 119 ft., cost $71.
Arapahoe	Deep well	700			NO FLOW	No artesian wells.
Gage						Well av. 74 ft., cost $63. Blow'g wells.
Beatrice	City well	1260	6	Few	FLOWS	Very salt, abandoned,
do	G. L. Hawkins	1260	6		do	
do	W. E. Robertson	1240	6		do	
Garfield						Wells average 143 feet, cost $87.
Burwell		268			NO FLOW	
Erina	P. A. McDonald	140	1¼		FLOWS	Soft water.
do	J. I. Connolly	115	1¼		do	do
do	Benj. Jones	175	1¼	5	do	Raises water 3 feet.
Gosper						Wells average 199 ft., $114.
Elwood	Deep well	327			NO FLOW	No artesian wells.
Grant						Wells average 74 ft., cost $37.
Hyannis	D. J. Plumer	450	1½	4	FLOWS	Cost $225.
do	do	300	1½	4	do	Cost $150.
do	do	465	1½		do	Cost $230. Flow increases.
do	do	460	1½	28	do	Cost $180.
do	Jas. Stansbie	625	1½	12	do	Cost $350.
do	S. S. Sears	413	1½			Cost $75).
Whitman	Sidney Manning	330	1½	6	do	Cost $150.
Greeley						Wells average 61 ft. Cost $36.
Brayton		102			NO FLOW	No artesian wells reported.
Hall						Wells average 46 ft., cost $25.
Cairo		110			do	No artesian wells reported.
Grand Island	U. P. R. R	36		750		
Hamilton						Wells vary from 90 to 160 ft. No artesian wells reported.
Harlan						Wells average 78 ft., cost $35. No artesian wells.
Hayes						Wells average 88 ft., cost $35.
Highland	Deep well	255			do	No artesian wells.
Hitchcock						Wells average 177 ft., cost $43.
Trenton	Deep well	234			do	No artesian wells.
Holt						Wells average 67 ft., cost $38.
Bliss	John Otter	105	1½	2½	FLOWS	Flow has decreased. Cost $83.
do	Wm. Jardine	125	1¼	25	do	Cost $50.
Deloit	G. E. Maybin	120	1½	50	do	
do	do	120	2	50	do	
Hooker						Wells 100 to 150 ft. No. art. wells rep.
Howard						Wells average 67 ft., cost $46.
Howard		1011				Unsuccessful. No artesian wells.
Jefferson						Wells average 95 ft., cost $73.
Fairbury	4 M. N. W				do	
	T. 2, R. 2, Sec. 4	500	4		do	Strong salt; temperature 70°. Seven borings for coal.
Johnson						Wells average 85 ft., cost $68.
Cook	J. W. Holden	80	2		do	Cost $20.
do	Frank Holmes	85	2	208	do	Cost $20.
do	C. R. Lahrack	80	3	53	do	Cost $38. Strong flow.
do	J. J. Wilson	80	2		do	Cost $30. do
do	do	80	2		do	Cost $30. do
do	do	80	2		do	Cost $30. do One of these keeps one-acre pond 4 feet deep full.
do	J. W. Cook	84	2		do	Cost $30. Has 4 artesian wells.
Kimball						Wells average 182 ft., cost $148.
Bennett	Deep well	460			NO FLOW	No artesian wells reported.
Knox						Wells average 108 ft., cost $74.
Herrick	T. C. Van Metre	504	2	2½	FLOWS	Flow decreased. Cost $225.
Niobrara	City well	656	8	2500	do	Cost $3500. Runs 60-barrel flour mill and electric light and raises water for the city. Remarkable well.
do		770	3		do	Head 80 ft., temp. 75°, 95 lbs. pressure. Cost $1100.
do	F. Nelson	600	2	280	do	Cost $350. Increasing flow.
	T. 32, R. 2, Sec. 17	420		50	do	
Santee Ag'cy		603	2½	20	do	

TABLE OF ORDINARY WELLS AND ARTESIAN WELLS—*Continued*

LOCALITY	NAME	Depth	Diameter	Yield per minute in gallons	Height of water in feet	REMARKS
Lancaster						Wells average 59 ft., cost $50.
Lincoln	Test well	2463		Many	FLOWS	Salt, flows into artificial lake, Burlington Beach.
do	Public square	1050		do	do	Salt, used for fountain.
do	Sanitarium	570	6	do	do	Salt, 2 wells, used to supply water for swimming pool.
do	David Swaney	240			do	Salt.
Lincoln						Wells average 120 ft., cost $80.
Watts	Deep well	300			NO FLOW	
Logan						Wells average 167 ft., cost $158.
Gandy	Deep well	318			do	
do	Lew Williams	81	2	Many	FLOWS	Soft water, cost $80.
Loup						Wells average 104 ft., cost $91.
Cooleytown	Deep well	269				
Taylor	Hy. Rainer	80	1¼		do	Hard water.
Madison						Wells average 134 ft., cost $89.
Tilden	Deep well	335			NO FLOW	
do	do	400				310 feet of water.
Norfolk	do	472				372 do
Warnerville	Aug. Tannehill	125	2	25	FLOWS	Cost $90.
McPherson						Wells average 87 ft., cost $46.
Lena	R. E. Haskell	42	2	4	do	Soft water, cost $25.
do	Whitew'tr Ranch	30		½	do	do do $15.
Merrick						Wells average 37 ft., cost $18.
Silver Creek	E. L. Tark	1700			1681	Negative artesian; water raised within 19 feet of surface. Cost $8000.
Nance						Wells average 176 feet, cost $128.
Geneva	Deep well	300			NO FLOW	
Fullerton	E. D. Gool	28	3			Water rises within 4 feet of surface. No artesian wells reported.
Nemaha						Wells average 62 feet, cost $66.
Brownville	Deep well	1001				
Brock	Geo. Young	52			FLOWS	Soft water.
Nuckolls						Wells average 51 feet, cost $34.
Mt. Clare	Deep well	535			NO FLOW	No artesian wells reported.
Otoe					FLOWS	Wells average 58 ft., cost $57.
Unadilla	E. Suff	220	1¼		do	Cost $175.
do	Hon. C. Darman	282	2		do	Cost $282.
Nebr. City		448	4	½	do	Min'l water, rises 6 ft. above surface.
Palmyra	Harry Hill	280			do	Salt water, 6 ft. above surface.
	Deep well	1000				
	do	570				Several deep wells in progress.
Pawnee						Wells average 65 ft., cost $82.
Dubois		562	6		NO FLOW	Unsuccessful.
T. 2, R. 9, S. 36	Wm. Patterson	85		1	FLOWS	
Table Rock	Deep well	354				
Perkins						Wells average 169 ft., cost $137.
Madrid	John McKenzie	150			do	Flow has incr'd. Soft water, cost $150.
do	Deep well	282				Unsuccessful.
Phelps						Wells average 150 ft., cost $68.
Loomis		250			NO FLOW	No artesian wells reported.
Pierce						Wells average 55 ft., cost $49. No artesian wells reported.
Platte						Wells average 106 ft., $67.
Monroe		580			do	
Joliet	David Thomas	113	2		FLOWS	Cost $100.
PlatteCenter	Eugene Bacon	100	2		do	These five artesian wells yield 65,000 gallons daily. Soft water; lifts water 20 ft. above surface. Many artesian wells 12 to 100 ft. 1 salt.
do	do	100	2		do	
do	do	100	2		do	
do	do	100	2		do	
do	do	100	2		do	
do	Robert Lewis	95	2	2	do	Cost $80.
Postville	Wm. Joseph	107	2	5	do	Cost $50. Soft water.
do	John Evans	95	2	47	do	Cost $65. do
do	W. R. Jones	95	2		do	Cost $60.
Polk						Wells average 119 feet, cost $74.
Thornton	Deep well	211				
Stromsburg	John Beckstrom	104	2		do	Cost $74.
Red Willow						Wells average 153 ft., cost $78.
McCook	Frank Nichols	405	6		do	Flow weak but increasing. Cost $302.

TABLE OF ORDINARY WELLS AND ARTESIAN WELLS—*Continued*

LOCALITY	NAME	Depth	Diameter	Yield per minute in gallons	Height of water in feet	REMARKS
Richardson						Wells average 60 ft., cost $62.
Falls City	Deep well	1300			NO FLOW	
Rulo	do	1370			do	Coal prospect.
						No artesian wells reported.
Rock						Wells average 92 ft., cost $44.
Basset	A. Jacox	95	1¼	6	FLOWS	Flow increasing, cost $33.
do	J. P. Broady	147	1¼			Rises within 3 ft. of surf'ce. Cost $57.
Hammond	D. Akin	139	2	15	do	Soft water, cost $105.
Newport	S. Klinesmith	50	1½	8		Water rises within 1½ ft. of surface. Cost $175.
Perch	Karl Lenke	149	2		do	Soft water, cost $50.
						Many artesian wells from 95 to 143 ft.
Saline						Wells average 89 ft., cost $66.
Wilber	Deep well	400			NO FLOW	No artesian wells reported.
Sarpy						Wells average 73 ft. cost $73.
Deerfield	Geo. L. Miller	1450	10			1,100,000 gallons a day; pressure 15 lbs. per square in. Supplies 30-acre lake for fish and ice. Soft water, cost $5000.
Saunders						Wells range from 30 to 451 ft.
Wahoo		152			do	
	S. ½ S. 36, T. 16, R. 8	323			do	160 feet of water.
	Sec. 1, T. 15, R. 8	275			do	do do
	Sec 6, T. 15, R. 7	451			do	
	Sec. 7, T. 15, R. 7	386			do	
	N.E. ¼ Sec. 12, T 14, R. 5	243			FLOWS	Good flow.
	N.E. ¼ Sec. 36, T. 13 R. 6	297			do	do Salt.
Scotts Bluff						Wells average 59 ft., cost $69.
Gering	Dr. Jas. Miller	330	2		do	Very weak flow, 30 to 40 gals. a day. Soft water; pump used now, cost $200.
do	A. R. Wood	331	6-4		do	Flowed for some time.
Seward						Wells average 91 ft., cost $47.
Seward	Deep well	346			NO FLOW	
Beav. Cros'g	W. L. Collier	103	1¼		FLOWS	Hard water, cost $31.
do	F. S. Johnson	124	1¼			The six artesian wells yield 260 gallons a minute, and cost $1200. Water medium hard. Used for irrigation and stock.
do	do	124				
do	do	124				
do	do	124				
do	do	131	8			
do	do	115				
do	J. P. Mayhew	107	2			Garden and fish pond, cost $47.
do	J. A. Cowperthwaite	105	3	Many		Fish pond, cost $40.
do	F. G. Furguson	120	4	70	do	Cost $75. Has 9 such wells and can irrigate 112 acres.
do	Argan & Foster	110	3	150	do	Cost $75.
do	John Arasmith	85	3	175		Cost $50. Hard water.
Seward	D. C. Work	610			NO FLOW	Abandoned.
						Many artesian wells 18 feet to 100 feet deep, costing from $18 to $100. Hard water.
Sheridan						Wells average 73 ft., cost $60.
Gordon	Deep well	582			do	Unsuccessful.
						No artesian wells reported.
Sherman						Wells average 84 ft., cost $55.
Ashton	Deep well	199			do	No artesian wells reported.
Sioux						Valley wells average 54 ft. Wells on table lands average 100 to 320 ft.
Harrison	Town well	320			do	No artesian wells.
Stanton						Wells average 162 ft, cost $128.
Stanton	Deep well	325			do	
T. 2, R. 3, S. 6	Dr. Person	96			FLOWS	Decreasing flow; irrigation, cost $77.
Thayer						Wells average 92 ft., cost $54.
Hubbel	Deep well	725			NO FLOW	
Alexandria						Mr. Emil Lange reports 15 artesian wells from 50 to 100 ft. deep.
Thomas						
Thedford						Wells at Thedford 125 to 160 ft. Few reports; no artesian wells.

TABLE OF ORDINARY WELLS AND ARTESIAN WELLS—*Concluded*

LOCALITY	NAME	Depth	Diameter	Yield per minute in gallons	Height of water in feet	REMARKS
Thurston	....	....	....	......	......	Few reports. No artesian wells.
Valley	....	....	....	......	......	Wells average 52 ft. cost $45. Several wells over 200 ft.
Ord	R. C. Schwann ...	70	2	15	FLOWS	Soft water; flows.
Washington ..	....	....	....	......	......	Wells average 104 ft., cost $89.
Fontanelle ..	Deep well	290	....	......	NO FLOW	
Hermann ...	Wm. Fitch........	76	1¼	.....	FLOWS	Good flow, soft water, cost $75.
do ...	W. M. Rutledge..	38	1¼	......	do	do hard do do $25.
do ...	Solomon Sheets..	37	1¼	3	do	Hard water, cost $25.
Wayne	....	....	....	......	......	Few reports.
Wayne	8 miles southeast P. Greenwood ..	...	....	.....	do	Artesian well, as reported.
Webster	....	....	....	......	......	Wells average 98 ft., cost $41.
Red Cloud ..	deep well.........	265	....	......	NO FLOW	No artesian wells reported.
Wheeler	....	....	....	......	......	Wells average 134 ft., cost $60.
Errickson	Deep well.........	905	....	......	do	
Bartlette....	J. G. Wolf	140	2	¼	FLOWS	Weak flow, cost $105.
Cumminsv'e	W. H. Mills	90	½	6	do	Soft water, cost $28.
do	W. M guery......	102	1¼	......	do	Cost $60.
do	L. M. Staple	104	1¼	20	do	Cost $75.
do	do	106	2	22	do	Cost $40.
Francis	H. H. Hoppe	115	1¼	3	do	Soft water, cost $82. Many shallow, inexpensive artesian wells.
York	....	....	....	......	......	Wells average 92 ft., cost $88.
York..	A. B. Codding....	600	4	......	do	Unfin'ed drill, past flowed. Clogged.
do	Eugene Wright ..	590	5	......	do	Soft water.
do	do ..	240	6	......	do	Salt water, cased off.

BLOWING WELLS

One rather phenomenal class of wells found throughout a large portion of the state, especially south of the Platte river, deserves particular notice, and is worthy of the critical and long-continued study which it is hoped it may yet receive. These wells are known by various names, "blowing," "roaring," "breathing," "singing," or "weather" wells, according to the widely separated communities in which they occur. It goes without saying that these wells are held in doubt elsewhere, but the fact of their existence is established beyond all question. In some communities, noticeably those of Jefferson county, all such wells are readily distinguished at a distance because of the mound of earth heaped up around the curbing and pump to check the wind. Frequently they are banked up with snow instead, and this soon becomes melted and riddled by numerous blowholes.

The attention of the author was first called to this matter by the numerous inquiries sent to his office for explanation of and the remedy for the freezing of well-protected pipes in wells at the apparently impossible depth of 30, 50, 60, 80, and even 120 feet below the surface. In every instance these were concerning roaring wells. There can be no possible doubt about the freezing of these pipes and but little doubt as to the cause.

Reports have come in from about twenty counties, distributed pretty evenly over the state, chiefly south of the Platte. The information is derived from land owners, farmers, well diggers, ministers, principals of schools, civil engineers, and students whose fathers own such wells, the only difference in the reports being that which arises from difference of observation. These accounts agree with personal observations. There are periods when these wells blow out for consecutive days and an equal period when they are reversed. This is tested with the flames of candles and by dropping paper, chaff, feathers, etc., into the casing to see it blown out or drawn in with some force. It is further stated that blowing often indicates high or low conditions of barometer, and that some wells blow most audibly when the wind is from the northwest, whereupon water rises to a higher level in the well than before; but when the conditions are reversed the air is drawn in, and in most reported wells the water is lowered. Many observers notice a reverse of the current according as it is morning or evening, and according as the temperature is high or low. During the progress of a low-barometer area over one of these regions the wind is expelled from blowing wells sometimes violently, and with a noise distinctly audible for several rods. Consequent to the approach of a high-barometer area the blowing becomes rapidly less until the current is reversed, when the high-barometer area is central over the region.

Steam or water vapor rises from the curbing, melting the frost or snow for several inches around it. Beyond this the well may be encircled by several feet of frost from the con-

densed vapor. Shortly after the current is reversed the thawed circle freezes again. Water vapor, coming from the stratum of invariable temperature, in winter is warmer when expelled than is the outside air. This may explain the fact that the pipes, if not too badly frozen, are often thawed out when the well blows. It is said that commonly inhalation (which carries the surface temperature to the bottom of the well, thus freezing the pipes), precedes the phenomenon of exhalation (which carries vapor at the average temperature of about 56°, and sometimes thaws the frozen pipes).

Experience has taught the people that the blowing of their wells is premonitory of an approaching storm; hence the name "weather" wells. This is an entirely reasonable and correct observation, for the falling barometer signifies a change of weather. The blowing means a low-barometer area, the sucking a high-barometer area. It is interesting in this connection to notice that the periods of most pronounced or unusual exhalation or inhalation are coincident respectively with periods of exceptionally low and exceptionally high barometer areas.

Professors Loveland and Swezey, of the Signal Service Station of the University of Nebraska, have made observations on such a well in Perkins county, the owners recording the hour when the blowing or sucking began. These, when compared with the records of the barometer, were exactly coincident. The citizens have elaborated many explanations, some of them as interesting as ingenious. Some reason that the blowing is plainly due to the liberation of natural gas; that natural gas is from petroleum; that petroleum is the natural distillation from great coal fields, and staking their fortune on this original reasoning they have spent no small sum, besides valuable time, in prospecting for coal. A few, noticing a change of current every twelve hours—that is, morning and evening—think the blowing wells are due to tidal action of the sheet water, considering the sheet water as a great subterranean lake. They should recall that the effect of tides on the Great Lakes themselves is scarcely appreciable; what, then, could it be in the sheet water?

The phenomenon is most generally attributed to atmospheric pressure, which is probably the true but not necessarily the sole cause.

It is plain that the air above and the air inclosed in the rock and gravel below are alike subject to the fluctuation of the barometer. If the surface air is rendered less dense by a low barometer, the air below will pass out by any opening, natural or artificial, until equilibrium between the rarer and the denser air is established, when they remain stationary. The reverse effect follows a high-barometer area. The author can not believe that this would account for the force displayed in the expulsion of air. Instead, the energy displayed seems due to the air forced out by the rising of the water below. Any force, barometric or otherwise, which would raise the water level in this layer would displace a certain amount of air. On the other hand, a lowering of the water table would admit a certain amount of air, but freedom of egress and ingress is retarded by roofing layers which are perforated here and there by an occasional well, and from such openings the air is expelled or drawn in. Confine this over a wide area, and it is apparent that a slight rise in water level would expel air from a well for several consecutive hours or even days. There is probably such close hydrostatic connection in the sheet water of the state that it is everywhere sensitive to differences of atmospheric pressure, and the difference is made sensible in certain localities by blowing or sucking wells. Awaiting the time when continued study shall have made exact explanation of this phenomenon possible, it is safe to attribute it to atmospheric pressure; but this is not the sole cause. The immediate effect is not so much the result of any one cause as of several. The observation is often repeated that wells blow and water rises appreciably when the wind is from the northwest. The wind is not so directly the cause as are the areas of low and high barometer, which travel ordinarily in this direction, accompanied by more or less wind. The wind may, however, be the immediate cause in some cases, especially in those

wells adjacent to the Platte river, and an indirect cause in others. At times, when a strong wind from the northwest prevails for hours, its impact against the river water—that is, the friction of the wind—is sufficient to drive the shallow water of the Platte river across its bed, leaving the irrigation ditches, the sand bars, and the interlacing channels on the north side dry, while those on the south side are flooded. That is, the waters are piled up there, as it were, and equilibrium disturbed. To that extent there must be readjustment. This is rendered sensible in the immediate vicinity by water rising in wells; at a distance by a wave of transmitted energy, which can but affect to a certain extent every portion of the underflow of the Platte. This may show itself in an appreciable rise of water and consequent displacement of air from porous strata, and an appreciable rise over a wide area might expel a large volume of air. Tests show that it is air, not gas, that is expelled. While exact records have been kept respecting blowing wells as far west as Perkins county, those farther east in Jefferson county, probably the most numerous and best known in the state, have received no critical study as yet.

IMPORTANCE OF WATER RESOURCES

In Nebraska, as in other portions of the Great Plains region, the principal source of wealth lies in the soil.

Except the soil and its products, the natural resources of Nebraska are few, and water, owing to its comparative scarcity and its importance in agricultural economy, rises to the rank of a mineral resource of the greatest importance. The development and employment of all of the supply flowing on the surface or percolating underground necessitates a study as thorough as that given by other states to coal, iron, or precious metals.

ACTION OF WATER UNDERGROUND

Air, which is the vehicle for moisture, can carry a greater load when it is dry, warm, and in motion. If the air is

cooled, it can no longer carry its burden, which is dropped from the clouds as rain. Follow the course of the raindrops, or circulating water, as it is aptly called, from the moment of impact with the surface and it will be seen that (1) a portion runs off, washing eastern soils badly, but washing western less; (2) a portion soaks in, since the soil is sandy, unlike clay soil; (3) a portion is evaporated, the average annual evaporation in Nebraska amounting to four or five feet; and (4) a portion, insignificant in amount, is taken up by plants and animals.

The portion that soaks into the soil sinks by its own weight deeper and deeper through the capillary or hair-like passageways and is lost to sight. It is universal experience

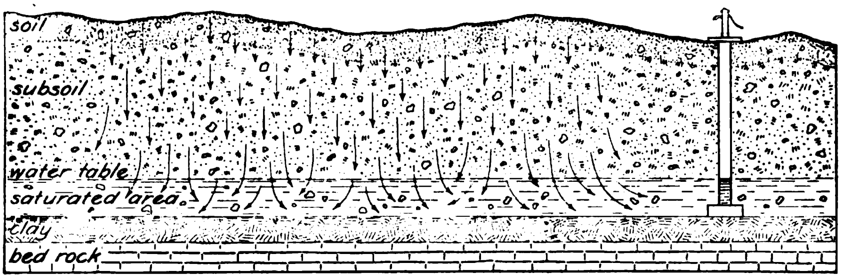


Fig. 35.—Course of water percolating from the surface down to the saturated area, wells being full to the water table.

that the soft, permeable surface material may change below to harder or even impermeable layers. Then it is that the water in its downward course is turned aside to flow laterally in all directions. Friction, however, greatly retards its movement. Constant additions are received as the rains continue, so the creeping waters pile up, as it were, and gradually rise higher and higher; that is, the water table or water plane is rising.

As the process continues the creeping layer must rise to or near the surface of the soil, and thus the ground becomes water-logged—that is, soaked or saturated with water. See fig. 35. At such times springs are flowing, the ponds and streams fed by them are full, wells are inexhaustible, and

vegetation is luxuriant and continues so during dry weather or even moderate drouth. Let the season of drouth continue and the creeping waters eventually steal away, and the saturated area is reduced to nothing; that is, the water table is settling. At such times ponds, springs, wells, and streams may fail—the more superficial first, the deeper last. Fresh showers cause them to slowly rise again, or perhaps they may rise without precipitation by accessions of water at some more remote spot, or from the seepage of some river swollen by floods at its source. Or, in still a third case, they may rise in an apparently mysterious manner without the intervention of showers or flood, simply because of hydrostatic connection with some other region which is flooded.

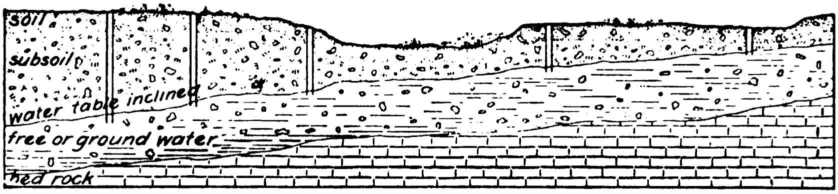


Fig. 36.—Inclined water table on an eroded rocky floor.

The water table, then, is subject to change because of water received at home or from abroad. It is not an entirely stable body preserving a constant level, but is subject to seasonal variations and variations incident to cycles of dry and wet years. The water table is not necessarily level, but is usually so, for instead of following the rocky floor the water table may run parallel with the surface.

The ground water, or free water as it may be called, is evidently in circulation and subject to fluctuation. The wells of the region likewise vary, although this is scarcely worthy of mention in the case of Nebraska, from the fact that nearly all of the counties report an unlimited water supply, with inexhaustible wells. When the water table rises to within half a yard of the surface, vegetation suffers or is drowned out. On the other hand, when the water settles too far, plants may suffer equally from lack of water to

carry soluble plant food to their roots and rootlets. When, however, the water table stands at a mean level between these two extremes, the fields of the state, with an annual rainfall of but 23.3 to 25 inches, produce crops and withstand drouth in a manner astonishing to the citizens of regions possessing double the annual precipitation. At first it seemed incredible that such magnificent yields could come from so insignificant a rainfall. Nevertheless, the fact stands. There are two apparent reasons for this. The rainfall in many eastern regions amounts to 35 or 40 inches, but one-half is lost by running off and carrying with it valuable soil fertility, the other half soaking into the ground, while in Nebraska the water lost as run-off is only about one-tenth. Hence, a far greater proportion of storm water is stored here for future use. This is largely due to the sandy nature of the soil. Even some of the so-called clay soils, though looking and acting like clay, are in fact exceedingly fine sand.

From the mechanical analyses of soils and subsoils made thus far it is shown that Nebraska soils are peculiarly rich in sands and poor in clays. The amount of sand—including in this term coarse, medium, and fine sand and silt—runs as high as 97 to 98 per cent. The lowest percentage thus far is about 66 per cent, while the average is probably about 78 per cent, based on the analyses made by Prof. Milton Whitney, of the Department of Agriculture. In a word, there is a preponderance of sand in Nebraska soils, which renders them at once light and capable of readily imbibing a larger proportion of rainfall than is possible in eastern states. This is a very significant fact.

The more one cultivates the virgin prairie, which when hard packed sheds water like a roof, the greater will be the amount of storm water caught and stored in the soil and the less the run-off and evaporation. Increased cultivation tends toward the conservation of soil moisture, and this in turn reacts, making it possible to catch more moisture, since soil already damp imbibes more rainfall than a dry soil. Thus as settlement goes on the amount of precipitation absorbed

increases and the amount lost becomes even less. This statement must not be confounded with the popular but erroneous belief that the annual precipitation is increasing.

When the spring rains cease and a season of settled weather or possibly drouth sets in, and the surface soil dries, a force of great interest and of profoundest importance begins to act. This force is capillarity, by virtue of which water is drawn up through the minute, hair-like passageways of the soil and subsoil, rising automatically as much as six or seven feet. This, then, is a second way by which water is held in the soil, and its far-reaching importance is instantly apparent when one considers that the very passageways up which this water is drawn are those down which rootlets grow. Soil moisture laden with soluble plant food is thus carried up to the rootlets or feeders of growing vegetation. Crops and grasses are nourished by capillary water and saved by it uninjured in time of drouth, even during seasons of long-protracted dryness (if not accompanied by hot winds), such as could not but blight crops and grasses elsewhere. However, it is not to be forgotten that this force works equally well both ways, thereby carrying moisture up or down, according as the surface soil or the deep subsoil is the drier. This only emphasizes the importance of utilizing all available rainfall in saturating the deeper soil as completely as possible, in order that the full energy of capillary attraction may be expended in drawing soil moisture to the rootlets.

Thus far two means have been considered by which water is held by the soil—first, as ground water, sinking by gravity, and, second, as capillary water. There is another means so subtle and concealed as to merit little more than passing notice—hygroscopic water, which is inherent in many minerals, rocks, soils, and substances, and may be obtained by long-continued roasting.

SHEET WATER

There is in common parlance a rather indefinite and puzzling use of the terms, first, second, and third water, and

sheet water. By first water is meant the first surface water that seeps into the well, a supply often weak and readily exhausted. By second or sheet water, as it is commonly called, is understood the deeper ground water, which is unlimited in amount, since it is contained in porous material that delivers water rapidly. Third water, as the term is popularly used, is doubtless the same second water struck at a lower level, after passing through a local layer of fine material of slow delivery.

Sheet water is a greatly abused term, about which has gathered false impressions not easily dispelled. It carries with it wherever used the idea of subterranean water flowing at an exaggerated rate under ground. It is perfectly true that ground water flows and that it has certain channels, naturally decided by the coarseness or fineness of the material, but one hears repeatedly of well diggers striking subterranean currents of sheet water flowing at the apparently incredible rate of four or five miles an hour, a faster rate than that of the Platte itself. This fallacious statement is made repeatedly in all sincerity and good faith. A very popular conception of this torrential sheet water is that it is the angry and pent-up floods of subterranean caves, which are seeking outlets to the sea. This erroneous conception is entirely fallacious and misleading.

There is no such current in the sheet water, and there are no such extensive caves and underground lakes, and can not be in the sandy soil of Nebraska. Caves are formed in limestones, not in sands, for naturally the sand would cave in and fill any great underground passageways as fast as formed. This misconception comes about naturally enough in some cases, and is cherished with a faith not to be shaken. The well digger, who, while bailing or pumping out water on one side of the well, sees it flowing in from the other, can tell without hesitation in which direction the water flows, for he "has seen it himself;" but let him set his pump on the opposite side of the well and the current will set in from the other direction.

Of course there is a current whose rate is regulated by the coarseness or the fineness of the material through which it flows, but this same current is inconceivably slow. Coarse material with rapid delivery of water may have a current as slow as a fraction of a foot a day, or as rapid as several feet a day, while in fine-grained, compact soil the rate is reduced to little or nothing. A better understanding of the power of delivery of various materials would correct many of these errors.

If an old pail or keg, having holes in the bottom, is filled with clean, coarse pebbles, and a stream of water poured in, the rate of delivery is practically as rapid as the rate at which the water is poured. Its rate is so rapid that the water flows down through the gravel in a column, scarcely wetting the other pebbles. With sand, however, the water spreads out or is diffused through much or all of the mass, and is delivered slowly at the bottom. In silt, which is impalpably fine sand, the rate is still slower, and the whole mass is saturated with water. In clay—the fineness of which is extreme—there is no delivery at all in experiment and practically none in nature. Mix together gravel, sand, silt, and clay, about as they occur in nature, and the rate becomes about the same as that of the finest material—that is, water is delivered with extreme slowness.

This set of experiments tends to show the rate at which water can flow through soil or rock of various degrees of porosity, and disproves the statement that the velocity of underground currents is in any way comparable with that of surface streams.

CONSERVATION OF SOIL MOISTURE

The importance of the conservation of moisture has not yet had the general recognition which the subject merits. But each year brings unmistakable advance in this matter, as is shown by the construction of new reservoirs and dams across streams and draws, and by new methods of cultivation. These are on the increase, and were it not for the diffi-

culties in the way of making water-tight reservoirs in sandy soil and the large amount lost by evaporation (averaging $4\frac{1}{2}$ feet for the state), greater progress might be reported. The matter of conservation of soil moisture by superior cultivation, being a less obvious factor, is lost sight of by many, and yet by this means there have been, to the author's knowledge, some marked examples of success, standing in strong contrast to the failure of others. By pulverizing to extreme fineness a coarse soil, the absorption of water may be increased a thousandfold. Compress or "firm" the soil, and the attraction of capillary water is increased to that extent. Mulch the surface into fine, loose particles, and the capillarity which draws the moisture up to the plant rootlets is broken at that point, and a blanket is formed for the retardation of evaporation and retention of moisture in the soil. By careful and intelligent farming, wide areas now abandoned, or held by indifferent, roving classes, will prove to have ample moisture for agriculture.

During the last five years various means for catching and holding surface water have increased enormously, and now attention is directed to the results consequent upon the better conservation of soil moisture, all of which will aid in the reclamation of important tracts of remarkably productive land now idle and unoccupied. There are table lands 200 to 300 feet above water where no amount of conservation of moisture on the surface or in the soil can avail; but, on the other hand, there are countless regions to be benefited thereby. Such table lands, therefore, where grazing is notably good, should be turned over to stock raisers, and the lowlands to agriculturists. Each class would prove of benefit to the other. Community life could be enjoyed in the valleys and the uplands left for grazing.

It is universally conceded that cattle raising is profitable, and that the small herder can make steady gains by watching his cattle more closely instead of turning them loose upon the range as formerly. It is an easy way to turn stock upon the common range, where no care is required, winter

or summer, except at the time of the annual "round up," but by that method the chances for loss are greater. Its day is past in Nebraska, and it is now time for many small cattle raisers to occupy the land once grazed over by the herds of great companies. The grazing lands should be turned to better account, the conditions of the valley lands should be better understood, and many important tracts now deserted should be reclaimed. This will come about by the storage of storm waters, by irrigation, and by the conservation of soil moisture.

POLLUTION OF WATER

Water for domestic supply is ordinarily well purified. In the river current the water is exposed to the air, and thus purification by the process of oxidation goes on. The ground water is likewise purified. But in its descent through the air, in its passage down the streams or through the soil and rocks, water, which is the universal solvent, takes up certain acids and gases and dissolves certain minerals, particularly lime (making hard water), iron (making chalybeate water), potash or soda (making alkali water), or salt (making saline water).

These are wholly inorganic ingredients and for the most part harmless. But there are other ingredients not to be detected by the sense of smell, sight, or taste, which come from organic decay. Water in closely settled regions is subject to dangerous pollution. It then becomes a vehicle for germs and contagious disease, and is not fit even for beasts. Wells should be so located and guarded that barnyard wash can not drain into them nor soak through the soil into them. The water filters through many feet of soil, and is pure and wholesome if proper precautions are observed. One may feel great confidence in the purity and healthfulness of water drawn from a well which passes through clay before striking water-bearing gravels.

The cities of the state should zealously guard against the possible contamination of their water. Good water for city

use is so easily obtained from groups or gangs of wells at reasonable depths that no community seems justified in drawing its supply from surface streams, which are subject to progressive deterioration as population increases.

FLUCTUATIONS OF WATER LEVEL

The years 1893, 1894, and 1895 were years of exceptional drouth. The whole water table was lowered, and springs, ponds, streams, and many wells failed. During the winter of 1895 there was virtually no rain or snow. That is to say, there was no precipitation by which to account for an unexpected rise of water (apparently real) which began early in the winter, and reached a point in February and March which aroused general comment. Many, during that time, had knots tied in well ropes whereby the well buckets might be lowered each time into the shallow water without roiling it. It was soon noticed that the wells were filling unexpectedly, because the ropes were wet some ten to twelve feet above the usual point. Water began to flow in channels hitherto entirely dry. The dry beds of ponds began to fill. Excavations for railroad embankments became lakelets. Springs which three years previously had supplied fish ponds, but had become dry, began to flow again; and damp spots began to appear in some farms. So many cases were reported in person or by letter that the author took pains to send out several thousand inquiries over the state. Two-thirds of those who answered had noticed an unexpected rise of water; one-third had not. The evidence is almost conclusive that this is real, and is a matter of annual occurrence.

One explanation is that the decreased evaporation and the increased cohesion of water in winter allows more ground water to accumulate. The majority reported the rise as occurring in February. Stockmen in the most arid portions of Nebraska depend implicitly upon this rise of water, which they assert is of annual occurrence and independent of precipitation. This matter seems as worthy of critical study as any problem connected with our ground water.

SALT WATER

Throughout southeastern Nebraska salt wells are so numerous that it is often uncertain how to avoid them. In pools, surface wells, and deep wells a strong brine is often met. The most conspicuous salt marsh is that of the extensive flat on Salt creek, near West Lincoln, which has been retained by the state as public land.

Here at one time a considerable industry sprang up, and, as the early founders of the state had hoped, salt was produced and shipped to neighboring states. Here the early freighters to the mountains bought their supply. With the discovery of the salt beds of Kansas, however, this industry could no longer survive. This basin, which is a mile or two across, is apparently depressed below the surrounding level, and one side has been cut away by a small stream. Though standing for a number of years as waste public land, it has recently been leased from the state by an enterprising company who, by damming up one side of the salt basin and setting the water back about one and a half miles, made a salt lake. Groves were planted around it; pavilions, bath houses, and restaurants were built; a small steamer and numerous sail and row boats added, and the whole given the rather pretentious name of Burlington Beach. See fig. 23. For several years this furnished inland people with an attractive pleasure and health resort. Any decline in this undertaking is to be viewed with regret by people living so remote from all aquatic scenes and sports. Numerous salt springs rise from its bottom and along its sides, thus supplying it with salt water. In addition, the abandoned test well (bored to a depth of 2,463 feet) is feeding into it a 6-inch stream of salt water.

In ordinary wells it is often found that fresh water can be drawn from the top and salt water from the bottom. The fresh water floats because of its lower density as compared with salt water. Considerable care is exercised in such cases in lowering the well bucket, so that the water may be agitated as little as possible in order to prevent the

salt and the fresh water from becoming mixed. In one well the pump is so arranged as apparently to yield salt water or fresh water from the same pipe by placing one pipe inside of the other.

Wells in southeastern Nebraska in the region of the Carboniferous below a depth of 150 feet are liable to be or to become saline.. Below this to a depth of 500 to 1,000 feet or more salt water is to be more or less expected. The salinity is greatest at 250 to 300 feet. It is strong at 500 feet, and the water is distinctly salt at 1,000 feet. When the well at Beatrice, 1,260 feet deep, was bored for the city supply the quantity but not the quality of water was expressly stipulated in the contract. When all the requirements were met the city refused to honor the bill because the water was salt. Losing the suit which followed, the contractor proceeded to make the best of a bad job by pulling up the pipe of this artesian well for use elsewhere. This would undoubtedly have saturated the drift of the region, and so have rendered worthless all the wells in and around Beatrice, but this was promptly averted by purchasing the pipe from the contractor. This saline well was still flowing when last visited.

The Riverview Park artesian well in Omaha, 1,060 feet deep, passed almost through the saline layer, but still is noticeably brackish. See fig. 32.

So far as can be learned, the first recognition of the hygienic possibilities of the saline water and its first utilization was by a former hotel proprietor in Lincoln, who is reported to have earned a considerable fortune, due largely to the salt baths which his hotel furnished. These salt baths were deservedly popular and enjoyed a local reputation, especially among those afflicted by rheumatism. At the present time their place is taken by the sanitarium of Doctors M. H. and J. O. Everett, called the Sulpho-saline Baths. This is an expensive and important institution, fitted with a great plunge and swimming tank 50 by 150 feet, and 3 to 10 feet deep, with baths and appliances of every description representing an investment of $100,000. Two artesian salt wells,

one 566 and the other 450 feet deep, fill the great tank, the water passing first through a heated coil and thence into the tank by its own pressure. This is the most important use to which salt wells in Nebraska have yet been put.

In several cases the waters of salt wells are bottled and sold, thus presenting a commercial aspect. The salt well, known as the Lloyd Mineral Well, at Union, Neb., is one of the best known in this connection. Its depth is 500 feet, and

Fig. 37.—Sulpho-saline Baths and Sanitarium, Lincoln, Neb., illustrating the utilization of saline artesian water. Swimming pool 50 x 150 feet, 3 feet to 10 feet deep.

the water is raised by a gasoline engine. Another economic feature is the proposed use of this water in certain manufacturing processes.

Several firms have already visited the region and speak favorably of locating in southeastern Nebraska, where salt wells can be obtained in connection with good shipping facili-

ties. On the Government square in Lincoln the salt water fed from a 1,060-foot artesian well is used to supply the public fountain. This water is carried away in bottles and pails because of real or imaginary curative properties, which almost any mineral water is reputed to have. The slightly saline water of the Riverview Park well at Omaha is put to a similar, though much larger use, because of the great volume of water supplied. It supplies a public fountain in the park,

Fig. 38.—Utilization of saline artesian water for a public fountain on the Government Square, Lincoln, Neb. Depth of well 1,060 feet. A section of this well may be found under Carboniferous formation.

from which a lively little cascade falls into the lake. The economic importance of this one well to the city of Omaha may be better judged when it is learned that an equal amount of water supplied by the water company at the lowest possible wholesale water rate would cost the city $5,000 annually.

Such wells may seem to be of little direct benefit to a community, yet anything which tends to beautify our prairie towns and cities and render them more sightly and attractive is undoubtedly of indirect value. The simplest fountain in our prairie towns becomes the more attractive from the very lack of rocks, springs, and brooks.

A rather novel if not unique method of irrigation by means of salt water is in vogue with market gardeners along Salt creek. The water of this creek being too saline

for direct application to the land, is used to turn paddle wheels, which at first sight might be mistaken for current wheels. Here is an example of the utilization of salt water in running undershot wheels and pumping fresh water for irrigation.

Fig. 39.—Head of the Goold-Hollingworth seepage or underflow ditch, dug about 12 feet below the surface in the dry sands of the North Platte valley, at Ogallala, Keith county, Neb.

METHODS OF RAISING WATER

Since water comes to have a high money value in a region rich in soil but poor in rainfall, the question of lifting water cheaply and rapidly becomes a subject of much importance and engages the serious attention of so many of our citizens that some remarkably interesting inventions are the practical result. Peculiar and characteristic systems of hoisting water are in vogue in widely separated counties, and however crude some may appear to be, they represent a move-

ment toward the solution of an important agricultural problem. Whether it be for the house, or for the cattle or sheep on the ranch, or for the larger work of irrigation, the ques-

Fig. 40.—The same ditch looking toward the head of the ditch from a point three-quarters of a mile below.

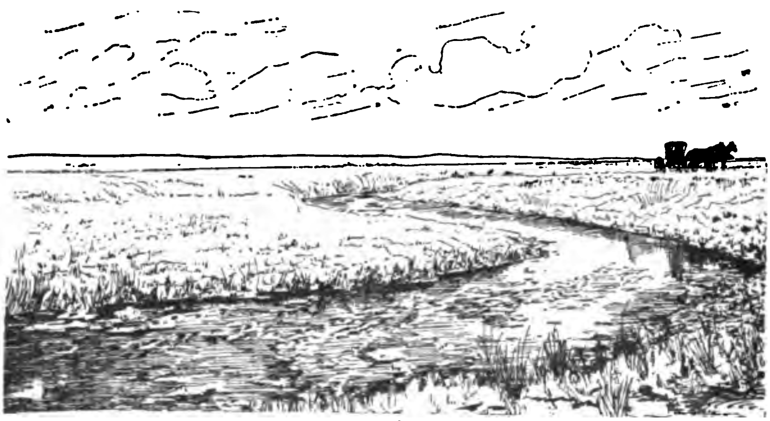


Fig. 41.—The same ditch seen a mile or so further down, where it enters the meandering channel of a former stream.

tion of getting water is of consequence. The easiest method is to let water come to the surface in streams, springs, and artesian wells. Where this is not practicable, recourse must

be had to the various water lifting devices hinted at here, chief among which are the pump, the endless chain and buckets, and the current wheel. Thousands of windmills are in daily operation, saving labor in pumping, many of them being of home-made construction, and, where the windmill is not efficient enough, horse power and steam are used. Along many of our streams current wheels are to be seen lifting water for irrigation.

Fig. 42.—The lower end of the Goold-Hollingworth ditch, Ogallala, Neb., four miles from its head, showing its expansion into a lakelet with a flock of green-winged teal swimming upon it.

Some have found it expedient to dig back into the sands of valleys and thus get underflow or seepage water for irrigation. Probably the most interesting seepage ditch is that known as the Goold-Hollingworth ditch, at Ogallala, on the North Platte river. When visited and photographed, the sands of the North Platte were so dry and had been so dry for months before that it seemed like the bed of an abandoned river.

There was not a visible sign of water for miles, yet as a

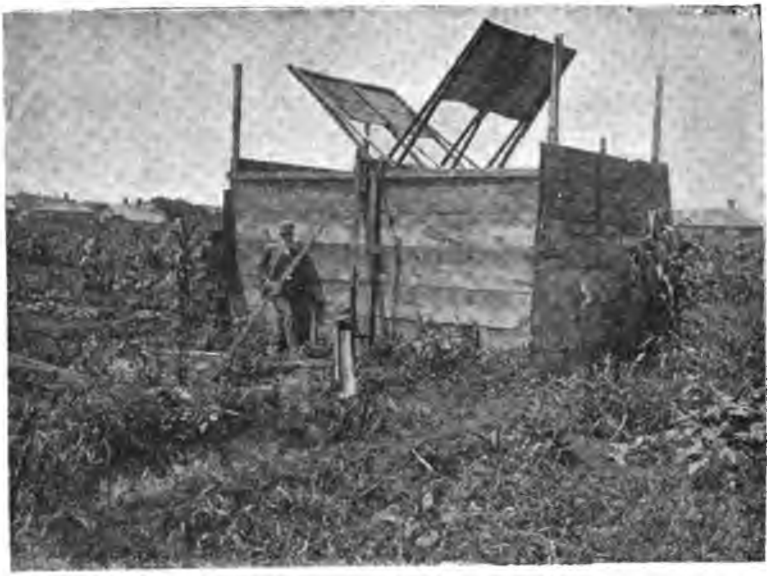


Fig. 43.—Jumbo windmill of the Travis Brothers, market gardeners, Lincoln, Neb., representing a type of home-made windmill commonly met with in Nebraska. This mill, which cost $8, was used to irrigate a five acre garden

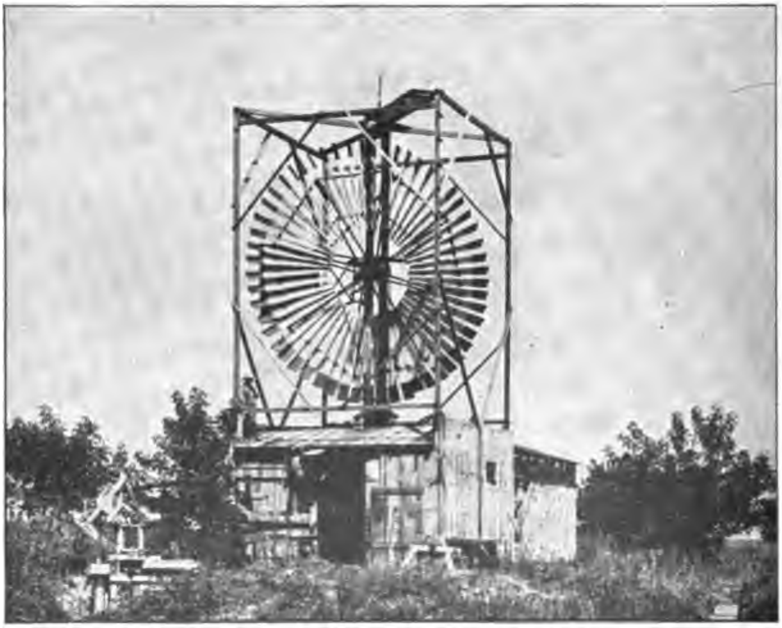


Fig. 44.—Giant turbine built by J. M. Warner, near Overton, Neb., a home-made windmill, diameter 18 feet, used in irrigating a 20-acre field of alfalfa and corn. Runs two 6-inch pumps, besides a corn sheller, corn grinder, and grindstone.

matter of fact underflow water was there, but deeper down in the sand.

Taking advantage of this knowledge, the Messrs. Goold and Hollingworth laid out a ditch from their ranches to a point some four miles up stream. They followed an easy grade and by the time they had plowed and scraped to the head of the proposed ditch they were down in the sand some ten or twelve feet.

Fig. 45.—Thirty-foot current wheel on a branch of Hat creek, Sioux county, Neb.; used in irrigating hay land.

At this point water flowed freely from what at the surface seemed to be perfectly dry sand. The stream was about twenty-five feet wide at its head, and increased in size to the lower end, which was swollen into a small lake. This ditch and others like it are capable of furnishing large amounts of water for irrigation, and for the benefit of those interested certain engravings are introduced to give somewhat better ideas of a seepage or underflow ditch.

GEOLOGY OF NEBRASKA

GENERAL FEATURES

The general reader is well aware that the geological features of Nebraska are obscured and often wholly concealed from public view by a deep mantle of soil. The student must often travel miles to find an exposure of rock, for it is only here and there that streams have worn away the mantle and laid bare the bed rock. A difficulty arises here in the matter of popular description, for the average citizen very naturally views this great mantle of soil as something simply to be plowed and harrowed, and as having little relation to geology. He views geology as beginning at bed rock. In other words, if the state were divested of all soil and soft surface material down to bed rock, it would represent a true geological map, according to popular conception. But why dig down to bed rock in making a map, when the surface material is a geological formation as much as though it were hard as rock instead of soft as sand?

The oldest formations are in the very eastern corner of the state, and younger and still younger formations appear as one travels westward, though generally concealed under a deep mantle of soil. The rocks of Nebraska are all undisturbed sedimentary rock, such as common sandstone, limestone, and clay or shale, and there are no native crystalline rocks, such as granite, marble, etc.

There are no rocks in the state older than those of the coal measure or upper Carboniferous, found in southeastern Nebraska. These rocks sag or dip to the west, and, by the time Lincoln is reached, have passed out of view, and are buried about three thousand feet in central Nebraska, and do not appear again until upturned along the Rocky mountains.

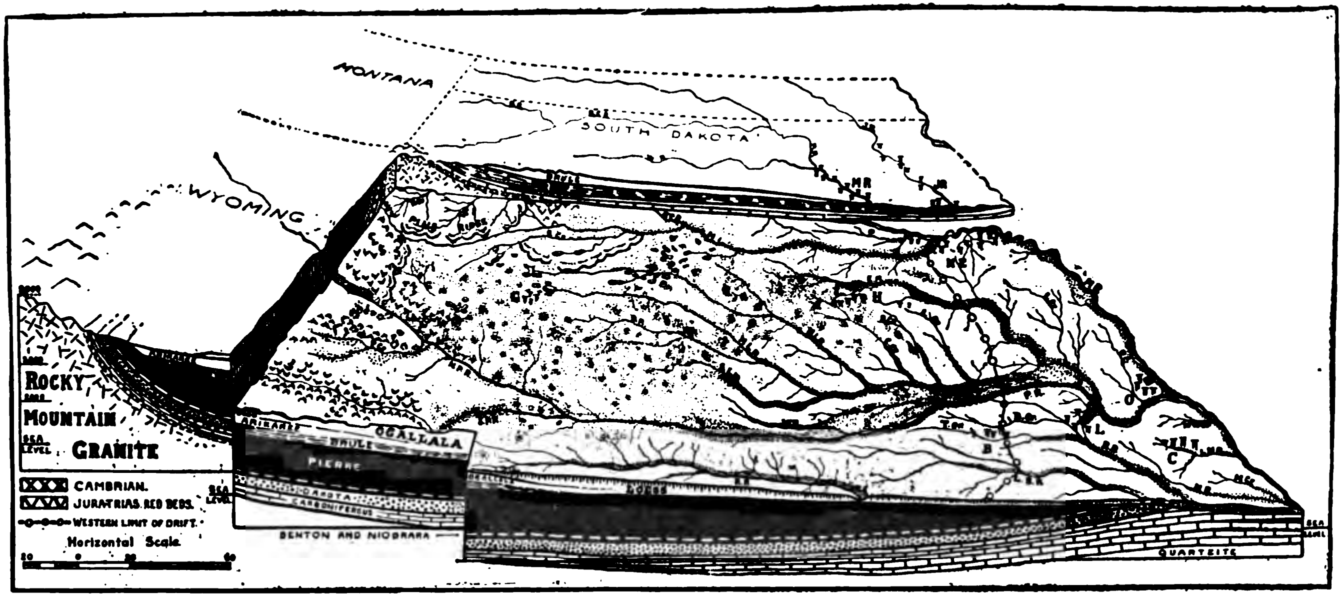


Fig. 46.—A general geological section of Nebraska along the southern boundary westward to the Rocky mountains. Also a section north and south as far as the granitic axis of the Black Hills, showing hydrographic regions, lakes, artesian basins, sand-hills, and topographic divisions. B., Bluewater; B. B. R., Big Blue river; B. Cr., Beaver creek; B. S. Cr., Big Sandy creek; C. Cr., Cedar creek; D. R., Dismal river; E. R., Elkhorn river; H. Cr., Hat creek; J. R., James river, S. D.; K P. R., Keya Paha river; L. B. R., Little Blue river; L. Cr., Logan creek; L. N. R., Little Nemaha river; L. P. Cr., Lodge Pole creek; L. R., Loup river; M. Cr., Muddy creek; M. L. R., Middle Loup River; M. R., Missouri river; N., Niobrara river; N. R., Nemaha river; N. L. R., North Loup river; P., Ponca river; P. Cr., Pumpkinseed creek; P. C., Papillion creek; P. R., Platte river; R. R., Republican river; S. Cr., Shell creek; S. L. R., South Loup river; S. P. R., South Platte river; S. R., Snake river: W., White river; W. R., Wood river; W. W. Cr., Weeping Water creek. Principal artesian basins: B., Beaver Crossing; C., Cook basin; G., Grant county basin; H., Holt county basin; J. R., James river basin, S. D.; L., Lincoln basin; M. R., Missouri river basin, S. D.; N. E., Northeast basin; O., Omaha basin.

The trough thus formed is filled with layers of Cretaceous rock, which have a total thickness of three thousand to four thousand feet in central and western Nebraska, and reach the astonishing thickness of eight thousand to ten thousand feet in the Denver basin.

The Carboniferous and Cretaceous constitute our oldest rock, and upon them lie the newer rocks, conforming in general to the eastward slope of the state.

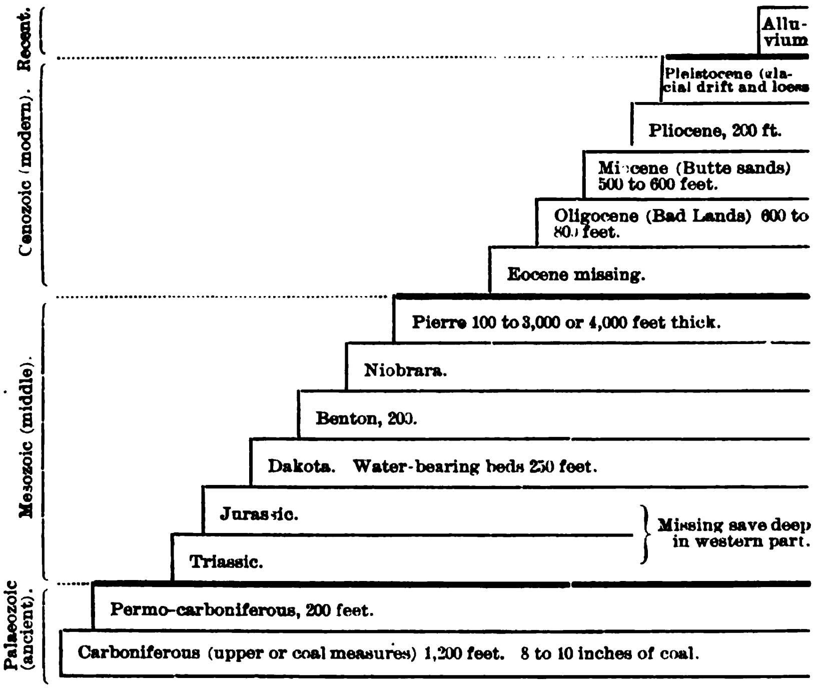
Those familiar with the succession of beds will observe that the Jurassic and the Triassic, representing a great lapse of time, are missing altogether, but are magnificently represented further west in Colorado, Wyoming, and Montana. The reason is that our neighboring states during that extended period were deeply submerged, and hence received deposits of all sorts, but Nebraska had emerged from water, and stood high and dry as a land surface, so, instead of receiving deposits, it was being carved and carried away.

There is only space enough at this juncture to allude simply to the geological ups and downs of the state, its salt water, fresh water, and land conditions. The eastern fifth of the state is covered by a fine mantle of glacial drift, overlain by a blanket of loess, sometimes exceeding one hundred feet in thickness. The glacial drift thins out rapidly and is hard to trace west of Seward, where it presents a ragged, obscure morainal front, but the loess continues diagonally across the state to the southwest. To the west, more particularly in the northwest, occurs the Bad Land clay (Oligocene). The Butte sandstone (Miocene) and the Magnesia (Pliocene) are widely distributed. The most recent deposits in the state, excepting of course the alluvial banks and bars forming at the present hour, are the level alluvial deposits of our streams, and certain drifting sand dunes.

GEOLOGICAL FORMATIONS

For those who are not familiar with a geological section and the succession of strata, it may be helpful to ascend the geological stairs, a step at a time, from the oldest beds to

the newest. This graphic method has the merit of brevity at least.



A more technical section may be found in connection with the colored geological map of Nebraska.

CARBONIFEROUS FORMATION

The Carboniferous, consisting principally of magnesian limestones of Missourian age, interbedded with shales and some sandstone, and aggregating a total thickness of about 1,200 feet, is by all means the most important geological formation in the state, at least from an economic point of view. It supplies the bulk of our building stone, our clay and lime, and, though the Carboniferous area is small, occurring in but a few of the southeastern counties, namely, Richardson, Pawnee, Nemaha, Johnson, Otoe, Cass, Sarpy, Douglas, and Washington, it is important. A large number of industries are founded on its natural resources, which

will be described in detail in succeeding reports. At present we must consider the Carboniferous simply as a bed of rock, outcropping along certain stream beds in the above counties, then disappearing from view. The name Carboniferous carries with it the idea of coal, and it is true that our Carboniferous bears a thin seam of coal, but it thins out rapidly and disappears altogether. At best it is scarcely more than eighteen inches thick and can not be worked with profit.

It seems a sad loss of time and money, but nothing can prevent men from "prospecting for this formation" in central Nebraska, oblivious of the fact that it is probably more than two thousand feet below the surface near Kearney, and from three thousand to four thousand feet below ground at North Platte, and can not be found again until the flanks of the Rocky mountains are reached, where it is barren of coal. Thousands of dollars can be saved in Nebraska by this knowledge, for there are many engaged in the determined effort to find the Carboniferous in impossible places. An unfortunate aspect of this affair is that many people report their undertakings to the geologist and ask for advice, but are averse to receiving it. They seem to covet encouragement rather than to learn facts, and take exception in most cases if a report adverse to their views and expectations is rendered, and, stimulated by a desire to show that the judgment of others is in error, dig resolutely downward. In one instance a foreigner, at the cost of his farm, sunk four deep shafts, all within a couple of acres, for the purpose of demonstrating that the Carboniferous was there, as he knew. In another instance, a ranchman in central Nebraska, after drilling 600 feet, asked advice, and after getting it, drilled unsuccessfully 1,100 feet more, out of a spirit of opposition, as he plainly confessed. It ought to be made plain to all citizens, foreign as well as native born, that the geologist of a state in giving advice is actuated by right motives, otherwise he is unworthy of the trust reposed in him by the people whose interests he is supposed to serve in the strictest fidelity and in a manner free from prejudice.

Do not dig for Carboniferous beds west of Lincoln; they sink rapidly. Though found on the surface in eastern and central Lancaster county, they are 269½ feet below the surface at Lincoln, as shown by the test well at Burlington Beach.

The topmost 200 feet of our Carboniferous is called the Permian, or better still, the Permo-carboniferous. However, for the sake of simplicity, it would do if no distinction were made, and the two treated as one, which they may prove to be.

If you wish for an "ear mark" to aid in determining whether you have Carboniferous rock or not, look first of all for the little fossil shells which so closely resemble grains of rice that the rocks composed of them are called petrified rice by the people. This shell, called Fusulina, a sort of overgrown chalk shell, is almost universal in our Carboniferous rocks. See fig. 135, and pl. II. To verify this, scrutinize any piece in the quarry, or examine any foundation, or look at the building stones of the Capitol, Post-office, or the State University. This kind of shell affords the readiest means of determination; still there are other shells which will assist you in the identification of Carboniferous strata, and in the interests of quarrymen and teachers, pupils and citizens who may be concerned, a few of the most important fossils indicative of Carboniferous strata are shown, without description, in plate II, and a list of Carboniferous fossils is to be found on page 127.

The rocks of this formation are characterized by the occurrence of innumerable nodules of flint or chert, which prove quite detrimental to many beds. These nodules are in evidence in many of our foundations, and as time goes on they stand out in rather unfortunate relief. The limestone, being soft, weathers away, while the flint, being hard and resistant, is not affected. At the State University, after ten or twelve years, flint nodules are found projecting an inch or more from the face of certain foundation stones.

The Carboniferous is subdivided into five or six beds, of

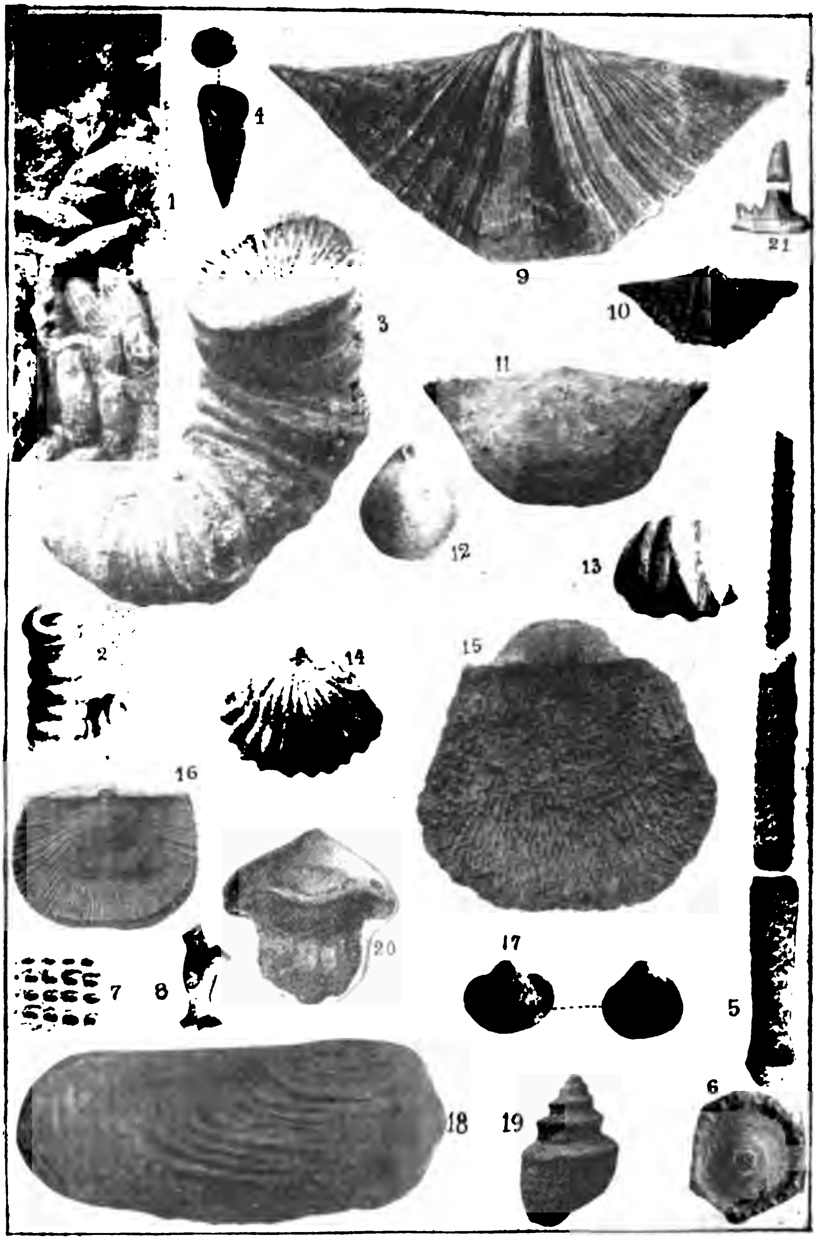
which the topmost, called the Cottonwood, and the underlying Atchison shales (Prosser's Wabaunsee), are the only ones of much consequence.

In the classification of the Carboniferous beds of this region the more conspicuous pioneers are Swallow, Meek, Hayden, and Broadhead. Swallow and Broadhead, in particular, have the undoubted right of priority, in that a full generation ago they studied the stratigraphy of Missouri, Kansas, and Iowa to Nebraska, recognized and named the successive beds, and described them minutely and unmistakably. However, some later writers, ignorant of their work or ignoring it altogether, have rechristened some of the layers. In the last decade, the stratigraphy of this same region has been studied by Keyes, Prosser, Williston, Beede, Haworth, Darton, and others. For ordinary purposes, a geological section of the Carboniferous in Nebraska, including the topmost coal measures, commonly called Permian, is about as follows:

PERMIAN (?)	Chase	Florence Flint—Blue Springs.
		Strong Flint—Holmesville.
	Neosho—Beatrice to Roca and Bennett (?).	
CARBONIFEROUS:	Cottonwood limestone,	
	Atchison shales, etc.	

EXPLANATION OF PLATE II

1. Fusulina secalica
2. Amblysiphonella prosseri, sponge
3. Campophyllum torquium, coral
4. Lophophyllum profundum, coral
5. Archaeocidaris agassizi, spine of sea urchin
6. Archaeocidaris agassizi, plate of sea urchin
7. Fenestelloid Bryozoan
8. Ramose or tree Bryozoan
9. Spirifer camaratus
10. Spiriferina cristata
11. Chonetes granulifer
12. Seminula argentea
13. Enteletes hemiplicata
14. Meekella striatocostata
15. Productus nebrascensis
16. Derbya crassa
17. Ambocoelia planoconvexa, ventral and dorsal
18. Allorisma subcuneatum
19. Pleurotomaria perhumerosa
20. Petalodus alleghaniensis, shark tooth
21. Cladodus occidentalis, shark tooth



A FEW TYPICAL FOSSILS INTRODUCED TO AID QUARRYMEN IN THE IDENTIFICATION OF CARBONIFEROUS ROCK

According to a section between Kansas City and Omaha by Charles R. Keyes, the following divisions are recognized:

Cottonwood limestone	10 feet
Atchison shales	500 "
Forbes limestone	25 "
Platte shales	105 "
Plattsmouth limestone	30 "
Lawrence shales	265 "
Plattsburg limestone	35 "
Parkville shales	75 "
Iola limestone	30 "
Thayer shales	50 "
Bethany limestone	75 "

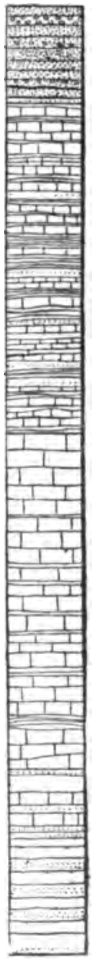
Iron pyrite, which ruins any rock containing it, damages some of our Carboniferous limestone, and other layers contain so much clay that they break down under the action of frost and rain in a season. Other beds are so full of fossils as to be rendered undesirable, while still other beds are compact, fine grained, uniformly colored, and altogether excellent stone.

The chief uses of our Carboniferous limestones are for foundations, concrete, lime, and for use in the manufacture of beet sugar, and for the smelter at Omaha.

The Carboniferous clays are of great thickness and of excellent quality, and a great variety of wares may be produced from them, and extensive clay industries are founded upon both our Carboniferous and Cretaceous clays, which are important commercially.

The coal found in the Carboniferous of our extreme southeastern counties is seldom over ten inches at best, though some beds are known where it is eighteen to twenty inches, and practical men have demonstrated, by repeated effort and failure, that there is little possibility of ever mining it profitably.

Shales in this formation are often very dark and compact, and so full of carbonaceous matter as to burn, but such beds must not be confounded with true coal.



			ft.
DAKOTA	Soil, sand, and gravel		48¼
	Sandstones, sands. Brine 21°		119
	Gravelly beds and clay. Brine 35°		195
			269 1/12
CARBONIFEROUS	Limestones and shales with occasional beds of sandstone.	Brine 12°	600⅛
		Brine 16°	828
		Coal, 4 inches	942
		Lowest fossils	1,099 1/12
AGE UNKNOWN.	Magnesia limestone.	Sandstone, 15 ft.	1,218½
			1,233 1/12
		Red shale	1,427¾
			1,440⅛
			1,813 1/6
TRENTON ?	Very fine blue limestone		1,847½
	Heavy dark magnesian limestone		1,947½
	Very fine blue limestone		2,008
SAINT PETER ?	Sandstone, 60¼ feet		
LOWER MAGNESIAN ?	Magnesian limestone, 113 feet		2,121⅛
POTSDAM ?	Red sandstone, 71½ feet		2,192¾
SIOUX QUARTZITE.	Quartzite and metamorphosed shale and quartz veins, color dark red to flesh.		2,463

Fig. 47.—Section of the test well at Burlington Beach, one mile west of Lincoln. This well was sunk by means of a diamond drill to a depth of 2,463 feet, and at a cost of $20,000 to the state, to determine the nature of our rocks, and whether gas, oil, or coal could be found. The core of this well is preserved in the State Museum at Lincoln.—After Darton.

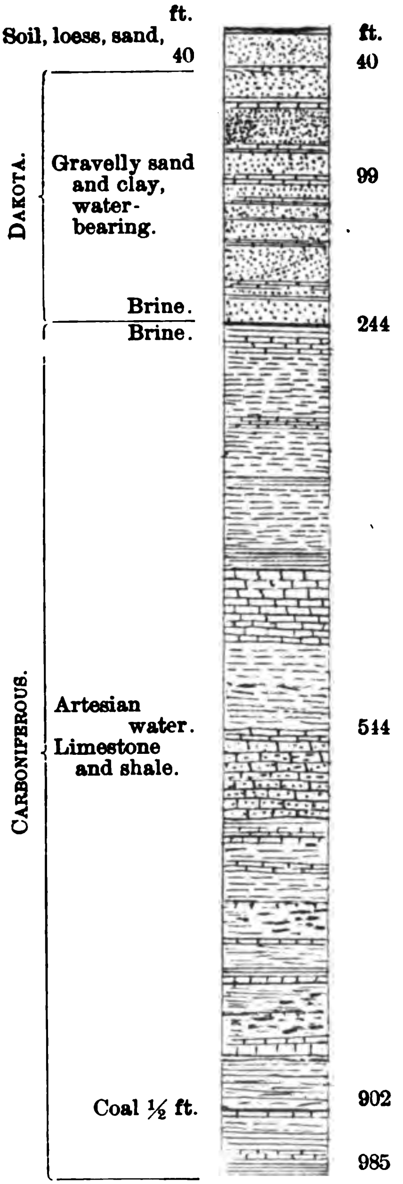


Fig. 48.—Section of the saline artesian well which supplies the fountain on the public square, Lincoln, Neb. —Fisher.

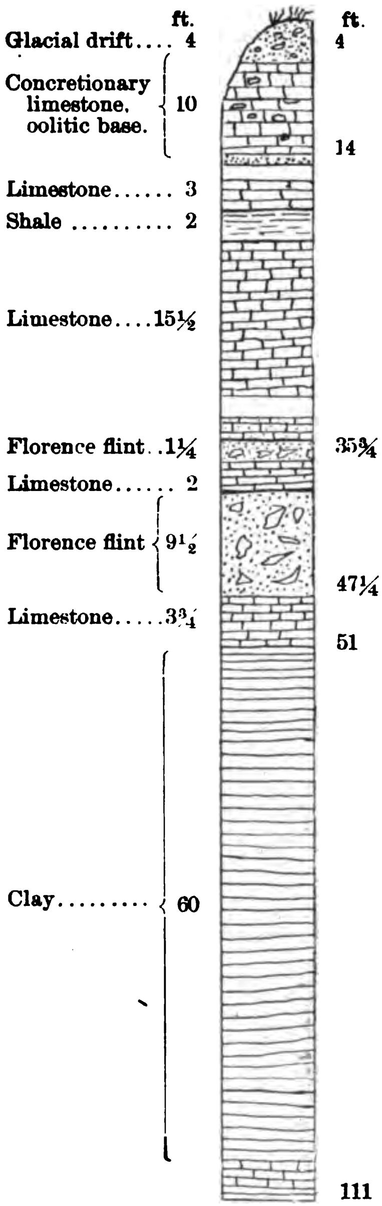


Fig. 49.—Section of Chase division of the Permian near Wymore, Neb. —Fisher.

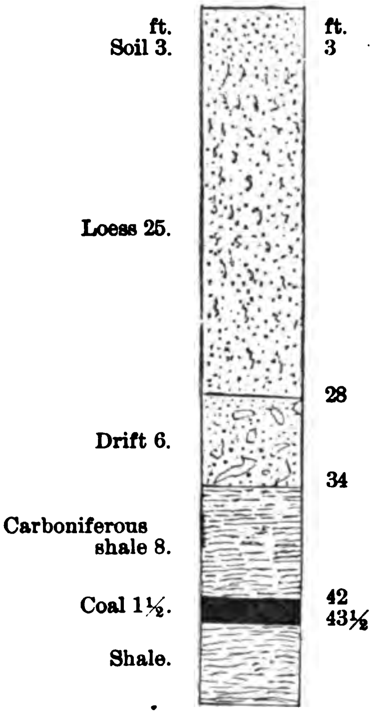


Fig. 50.—Section of coal pit 4½ miles southeast of Rulo, south side of the Nemaha, one mile above B. & M. bridge.

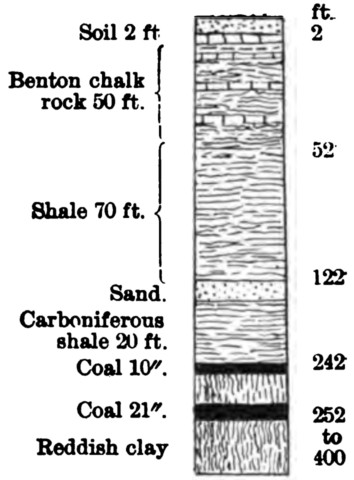


Fig. 51.—Section 6 miles west of Wilber, Neb., at James Mitchell's place, T. 6, R. 3, S. 22.

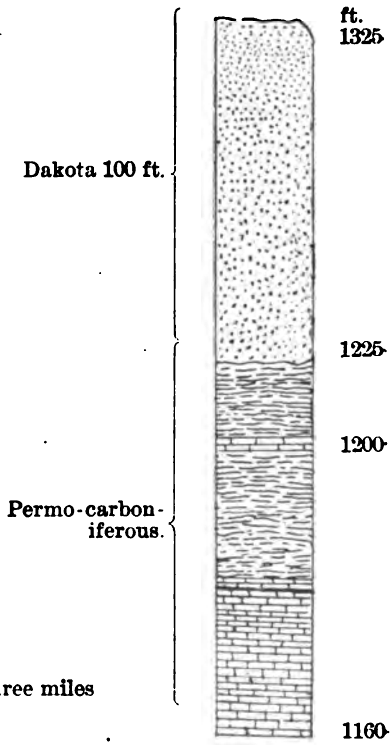


Fig. 52.—Section at "Iron Mound" three miles southeast of Beatrice, Neb.

FOSSILS OF THE CARBONIFEROUS OF NEBRASKA

PROTOZOA.—Fusulina secalica.

PORIFERA.—Amblysiphonella prosseri.

COELENTERATA.—Aulopora anna, Aulopora? prosseri, Campophyllum torquium, Lophophyllum profundum, Microcyclus discus M. & W., Stromatopora sp., Syringopora multattenuata, Zaphrentis sp., Zaphrentis sp.

ECHINOIDEA.—Archaeocidaris aculeata, Archaeocidaris agassizi, Archaeocidaris megastylus, Archaeocidaris? triserrata.

CRINOIDEA.—Barycrinus subtumidus, Ceriocrinus hemisphericus, Ceriocrinus missouriensis, Erisocrinus typus, Eupachycrinus? (rare), Hydeionocrinus kansasensis, Zeocrinus acanthophorus, Zeacrinus mucrospinus, Platycrinus sp.

VERMES.—Spirorbis sp., Serpula sp.

BRYOZOA.—Batostomella leia Condra, Cyclotrypa? barberi Ulrich, Cystodictya anisopora Condra, Cystodictya inequimarginata Rogers?, Cystodictya lophodes Condra (rare), Fenestella binodata Condra, Fenestella conradi Ulrich, Fenestella compactilis Condra, Fenestella cyclofenestrata Condra, Fenestella gracilis Condra, Fenestella polyporoides Condra, Fenestella limbata Foerste, Fenestella mimica Ulrich, Fenestella perelegans (Meek), Fenestella parvipora Condra, Fenestella spinulosa Condra, Fenestella subrudis Condra, Fenestella tenax Ulrich?, Fistulipora carbonaria Ulrich, Fistulipora carbonaria-nebrascensis Condra, Fistulipora nodulifera Meek, Meekopora prosseri Ulrich, Pinnatopora pyriformipora Rogers, Pinnatopora trilineata Meek, Pinnatopora youngi Ulrich, Polypora bassleri Condra, Polypora cestriensis Ulrich, Polypora crassa Ulrich, Polypora elliptica Rogers, Polypora remota Condra, Polypora reversipora Condra, Polypora spinulifera Ulrich, Polypora stragula White, Polypora submarginata Meek, Polypora ulrichi Condra, Rhombopora lepidodendroides Meek, Septopora biserialis (Swallow), Septopora biserialis-nervata Ulrich, Septopora cestriensis Prout, Septopora decipiens Ul-

rich, Septopora multipora (Rogers), Septopora pinnata Ulrich, Septopora robusta Ulrich, Stenopora carbonaria (Worthen), Stenopora carbonaria-conferta Ulrich, Stenopora distans Condra, Stenopora heteropora Condra, Stenopora? polyspinosa (provisional) Condra, Stenopora spinulosa Rogers, Stenopora tuberculata Prout, Steblatrypa prisca (Gabb & Horn), Thamniscus palmatus (provisional) Condra, Thamniscus pinnatus Condra, Thamniscus sevillensis Ulrich.

Brachiopoda.—Orbiculoidea convexa, Productus semireticulatus, Productus nebrascensis, Productus longispinus, Productus punctatus, Productus pertenuis, Productus cora americanus, Productus costatus, Productus magnus, Productus cora, Productus burlingtonensis?, Productus symmetricus?, Chonetes granulifer, Chonetes verneuiliana, Rhipidomella pecosi, Hustedia mormoni, Pugnax utah (Marcou), Ambocoelia planoconvexa, Seminula argentea, Enteletes hemiplicata, Derbya benneti, Derbya crassa, Derbya keokuk, Reticularia perplexa, Spirifer cameratus, Speriferina cristata, Meekella striatocostata, Dielasma bovidens, Lingula scotica-nebrascensis.

Lamellibranchiata.—Aviculopecten hertzeri, Aviculopecten carboniferus, Aviculopecten nebrascensis, Aviculopecten occidentalis, Allorisma sp., Allorisma subcuneatum, Allorisma granosa?, Chaenomya sp., Chaenomya leavenworthensis, Chaenomya minnehaha, Edmondia aspinwallensis, Edmondia per oblonga?, Edmondia subtruncata, Myalina sp., Myalina ampla, Myalina recurvirostris, Pinna? coprolitiformis Beede, Pinna peracuta?, Aviculopinna knighti Beede, Aviculopinna nebrascensis Beede, Pseudomonotis sp., Sedgewickia topekaensis.

Gasteropoda.—Bellerophon bellus, Bellerophon nodocarinatus, Bellerophon panneus, Capulus spinigerus, Cornularia missouriensis, Euomphalus latus, Euomphalus rugosus, Macrocheilus altonense Worthen, Murchisonia lasallensis Worthen, Murchisonia terebra, Natcopsis subovatus, Orthonema subtaeniata terebra, Pleurotomaria iovensis Worthen, Pleurotomaria missouriensis, Pleurotomaria perhumerosa,

Pleurotomaria spironema, Pleurotomaria subdecussata, Streptacis whitfieldi?, Strophostylus remex?, Trachydomia wheeleri?, Turbo sp.

SCAPHOPODA.—Dentalium sp.

CEPHALOPODA.—Nautilus ferratus, Nautilus spectabilis, Nautilus occidentalus, Nautilus ponderosus, Orthoceras sp., Orthoceras cribrosum.

CRUSTACEA.—Ostracoda; Phillipsia sp., Phillipsia major.

PISCES.—Campodus variabilis (N. & W.), Cladodus occidentalis Leidy, Cladodus knightiana, Cladodus sp., Chomatodus arcuatus (St. J.), Ctenacanthus amblyxiphias Cope, Cteroptychius occidentalis (St. J. & W.), Deltodus angularis (N. & W.), Fissodus inequalis (St. J. & W.), Helodus rugosus (N. & W.), Janassa maxima (M. S.), Janassa unguicula sp. nov. (M. S.), Peripristis semicircularis (N. & W.), Petalodus alleghaniensis Leidy, Streblodus augustus (M. S.).

PERMO-CARBONIFEROUS FORMATION

The Permian formation scarcely needs mention, for there is no break between it and the Carboniferous, and for practical purposes it is all Carboniferous.

The very topmost layers of the Carboniferous are called Permian, yet it may be that the Permian, in point of fact, began later with the Red Beds. Our Permian, which may be viewed as the finishing touch to the Carboniferous, is confined chiefly to Gage county, extending northward into Lancaster, and touching the western edges of Pawnee and Johnson counties, being exposed chiefly at Wymore, Blue Springs, Holmesville, Beatrice, and Roca.

The Permian is commonly subdivided as follows:

1. Red Beds. Wanting in Nebraska.
2. Wellington. In Kansas.
3. Marion. In Kansas.
4. Chase— { Florence flint, at Blue Springs and Wymore. Strong flint, at Holmesville. }
5. Neosho—Extending from Beatrice to Roca and Bennett(?).

The following sections, prepared by Dr. Wilbur C. Knight, may assist citizens in the region of the Permian to recognize layers:

Section at the old cement mills, three miles below Beatrice.

4. Soil and drift	4	feet
3. Yellowish shelly limestone	4	"
2. Cellular light grey limestone	13	"
1. Bluish hydraulic limestone	8	"
Layer No. 1, once used for hydraulic cement.		
	29	feet

Section at Holmesville.

5. Soil, sand, and drift	9	feet
4. Yellowish to bluish limestone with geodes	10½	"
3. Bluish limestone	4	"
2. Cherty limestone	6	"
1. Unexposed to the river	14	"
	43½	feet

Section 2½ miles southwest of Holmesville.

6. Cream colored limestone	5/6	foot
5. Cream colored limestone	2½	feet
4. Cream colored limestone	3⅓	"
3. Cream colored limestone	3	"
2. Cream colored limestone	3	"
1. Bluish and grey limestone	8	"
	20⅔	feet

Section at Blue Springs.

10. Soil	2	feet
9. Yellow shelly limestone	5½	"
8. Compact yellowish limestone containing vertebrates and many invertebrates	7½	"
7. Cherty limestone fossiliferous	1½	"
6. Yellowish, soft limestone	1⅔	"
5. Cherty limestone fossils in chert	16	"
4. Indurated and variegated marls	20	"
3. Bluish limestone	10	"
2. Unexposed	10	"
1. Bluish limestone	3	"
	77 1/6	feet

Section on the Kansas-Nebraska state line.

7. Yellowish oolitic limestone	8½	feet
6. Light colored limestone, shelly	4	"
5. Yellowish limestone	8	"

4. Light colored limestone with some chert	13	feet
3. Very cherty limestone	15	"
2. Indurated marls, variegated	15	"
1. Unexposed to river	20	"
	83½	feet

PARTIAL LIST OF FOSSILS, ACCORDING TO DR. KNIGHT

Nautilus eccentricus M. and H., Metacoceras dubium Hyatt, Metacoceras sp., Myalina aviculoides M. and H., Myalina peratenuata M. and H., Myalina permiana Swal., Myalina sp., Seminula argentea Shep, Pseudomonotis hawni M. and H., Pseudomonotis hawni ovata, Pseudomonotis sp., Meekella striatocostata Cox, Derbya crassa M. and H., Derbya robusta Hall, Aviculopecten occidentalis Schum., Aviculopecten sp., Bakevellia parva M. and H., Pinna sp., Yoldia subscitula M. and H., Schizodus sp., Schizodus sp., Solenomya sp., Solenomya sp., Fenestella sp., Pleurophorus sp., Edmondia sp., Scaldia sp. nov., Allorisma subcuneata M. and H., Bellerophon marcouanus Gein, Bellerophon sp., Avicula cf. lanceolata, Orthoceras sp.

The Permian is productive of clay, limestone, and chert, which is now being crushed and screened at the Atwood quarries for use as ballast, and for concrete for the B. & M. R. R. as described under flint. Its use ought to be generally extended, and no hesitancy need be felt in recommending it as a road-building and street-building material of importance.

DAKOTA FORMATION

The Dakota formation, so called because of the typical exposures found at Dakota City, Neb., is ordinarily spoken of as Dakota sandstone, for the reason that every one in eastern Nebraska is familiar with its very characteristic sandy layer, which has such a rusty or ferruginous appearance that once recognized it is never forgotten. In reality, there is as much clay as sand in this formation, and some of our best clay products come from the extensive and impor-

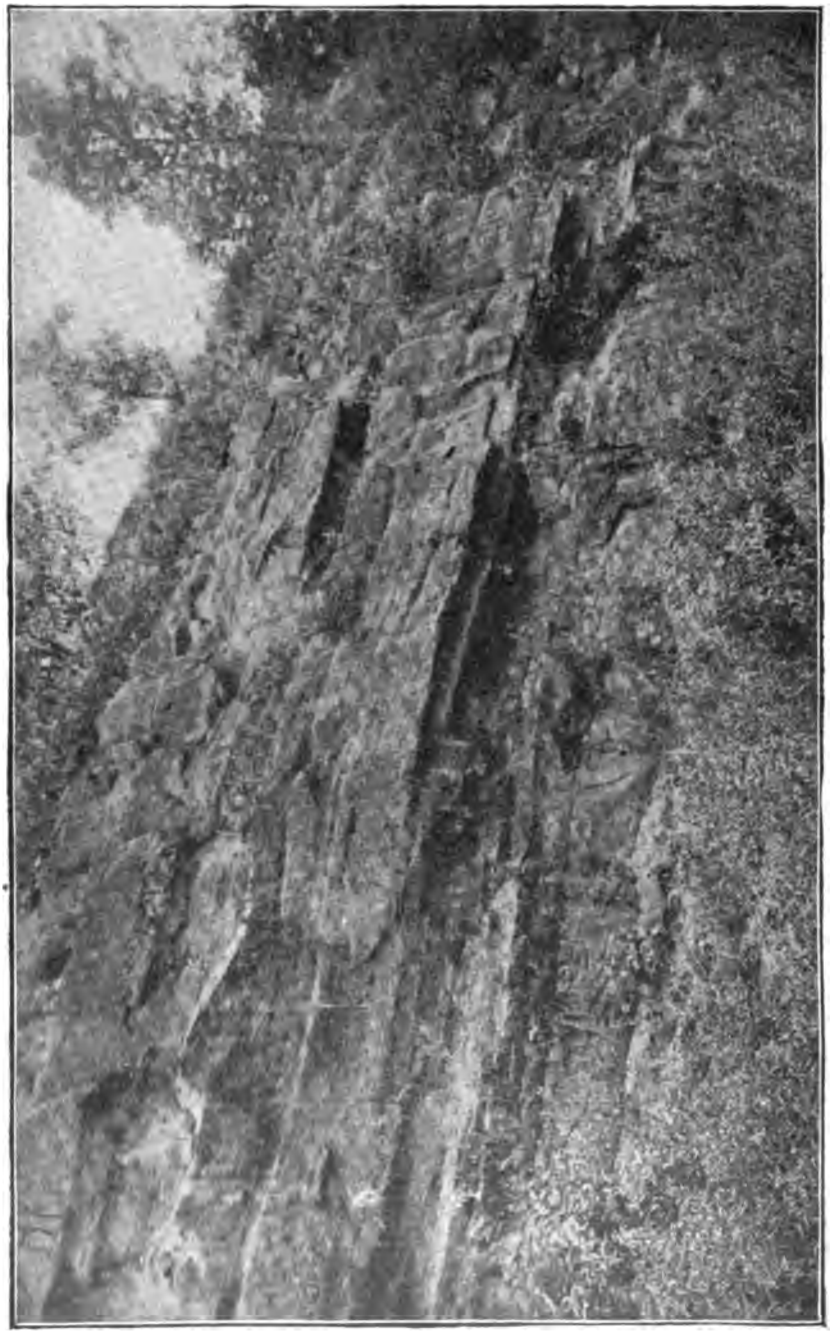


Fig. 53.—Sandstone of the Dakota formation on the west bank of the Missouri river at the mouth of the Platte river. Shows cross bedding and beds of coarse materials. Photograph by N. H. Darton, United States Geological Survey.

Fig. 54.—Sand pit just southeast of Bennett, Neb., in the Dakota formation, showing regular bedding and false bedding.—Darton.

tant clay deposits in the Dakota. It is characterized, in many places by the impressions of countless leaves, over five thousand specimens being displayed in the State Museum as the result of one summer's work.

The Dakota clays are yellow, blue, red, and mottled, and yield brick of any desired color or kind. The Dakota sands are mostly crumbly or friable; sometimes light in color, but generally dark, and strikingly rusty; in fact so heavy with iron in layers as to pass for iron ore. Here iron concretions or balls, often hollow within, are common, and since they resemble iron ore are often considered meteorites.

The Dakota sand rock is sometimes soft enough to be dug by the hand like sand; in some places it is half compact, and good enough for rough building purposes, in spite of its unfortunate dark brown or rusty color. In other places it is as hard as quartzite, as in the case near Fairbury, and in scattered exposures in the northeastern counties. Here the cement is lime instead of silica, and the rock is of an attractive color, fine texture, and densely hard. Unfortunately, in the quarries producing this grade of stone, there are innumerable fossil leaves of a dark color, twigs and limbs converted into iron pyrites, besides scattered crystals, and bunches or nodules of pyrite, which quickly oxidize on exposure. The rock which at sight seems so presentable is streaked with iron-rust in a season, and its value as an architectural stone is ruined. This rock will surely be found in various quarries in eastern Nebraska free from this blemish.

All of the sandstones of the Dakota tend to be rather coarse grained, with certain exceptions, and so deliver water

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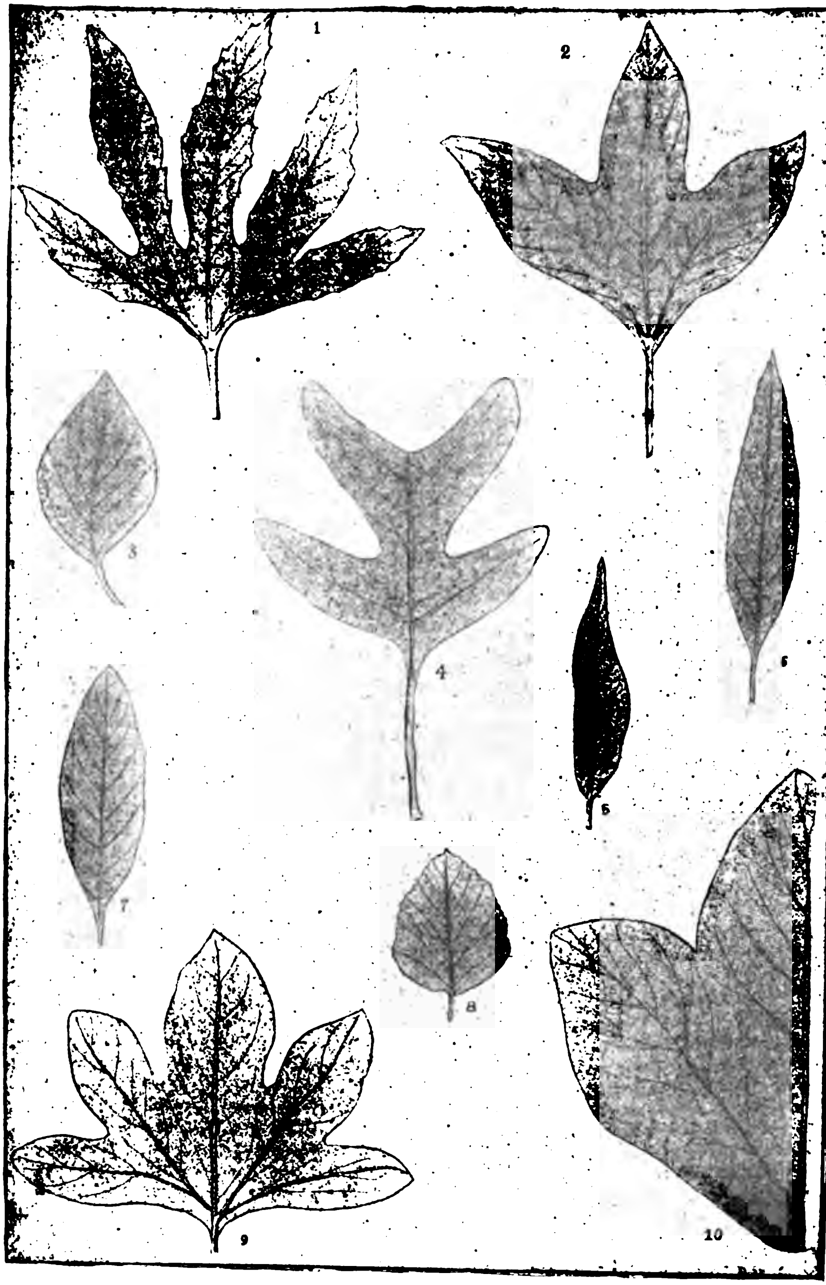
EXPLANATION OF PLATE III

Fig. 1. Aralia wellingtoniana Lx.
Fig. 2. Sassafras cretaceum Ny.
Fig. 3. Populus kansaseana Lx.
Fig. 4. Liriodendron giganteum Lx.
Fig. 5. Salix proteaefolia Lx.
Fig. 6. Ficus proteoides Lx.
Fig. 7. Magnolia boulaynna Lx.
Fig. 8. Betulites westii var. latifolius Lx.
Fig. 9. Liquidamber integrifolius Lx.
Fig. 10. Aspidiophyllum trilobatum Lx.



FOSSIL LEAVES CHARACTERISTIC OF THE SANDSTONE OF THE DAKOTA CRETACEOUS

rapidly; but around Louisville the coarse sand becomes pebbles, constituting a conglomerate many feet thick, held together in places by a heavy iron cement. The white quartz pebbles and the dark cement closely resemble the peanut candy of the confectioner, and are very appropriately named peanut rock. Large amounts of this pebbly gravel are shipped to cities and towns to be used on walks, drives, tar-roofs, etc. Whether fine grained or coarse, there is a marked tendency in all of the Dakota group to show cross bedding, or false bedding. The Carboniferous must have been cut into hills and hollows and irregularities of surface before the Dakota was laid over it. Many exposures along the Platte, at Roca and Bennett and southward show the Dakota beds resting as they do, directly upon, but unconformably with the Carboniferous. The line of contact is very distinct, the one above being brown or rusty sandstone, the other lying under it being light colored limestone.

In the vicinity of Fairbury there are large exposures, and near Wymore an exposure is known as Iron mound; also at Saltillo, Rokeby, Pleasantdale, and Emerald patches of Dakota are laid bare. At Lincoln it comes close to the surface, and wells are often dug in it for water supply, and once in a while it outcrops, as at the Mockett well in the Antelope valley, at the Lincoln brick and tile works of West Lincoln, at the "Cave," Penitentiary hill, and Yankee Hill brickyard and beyond. Scattered patches are to be observed from Lincoln to Crete.

North of Lancaster county it is practically concealed everywhere by glacial drift and loess. The Platte has washed the drift and loess away and has cut its banks, thus laying the Dakota bare in many places. North of the Platte it is buried, but is exposed along the Missouri river from Burt county to Dixon county. Although there is a strip of Dakota running nearly north and south for 200 miles, it is so completely buried by the loess that it is seen only in widely separated exposures where an occasional stream lays it bare.

In the test well at Lincoln, the Dakota was thought to have been struck at 48½ feet and was pierced at 269 feet, making its thickness about 221 feet at that place. Its thickness may safely and conveniently be estimated at 250 feet in round numbers. Its thickness in South Dakota is about 200 to 500 feet.

The economic importance of the Dakota formation lies chiefly in its excellent clays, in the water which it supplies, and in its stone. Some of its stone is good for foundations and even for buildings. People who wish to determine whether their quarry belongs to the Dakota group will look, first of all, for the rusty brown sandstone, and for the cannon ball concretions and petrified leaves. The impressions of these leaves are very nearly perfect, and show that the Cretaceous trees were very like modern ones; that is, there were sassafras, gum, poplar, willow, oak, magnolia, etc.

To aid citizens in the work of distinguishing this from the beds of Carboniferous rocks below and Benton above, a few of the more important fossil leaves and shells of the Dakota are introduced in plates III and IV.

EXPLANATION OF PLATE IV

Unio barbouri

Fig. 1. Side view of an artificial cast from a natural mold.
Fig. 2. Dorsal view of the same specimen.
Fig. 3. Side view of an artificial mold of a natural cast of a right valve of another specimen of the same species.

Unio (doubtful species)

Fig. 4. Side view of a natural cast of the interior of the shell
Fig. 5. Dorsal view of the same specimen.

Corbula hicksii

Fig. 6. Side view of the left valve; an artificial cast from a natural mold.
Fig. 7. Dorsal view of the same specimen.
Fig. 8. Front view of another specimen; also an artificial cast of a natural mold.

Goniobasis jeffersonensis

Fig. 9. Side view of an artificial cast of a natural mold.

Goniobasis (doubtful species)

Fig. 10. Side view of an artificial cast of a natural mold.

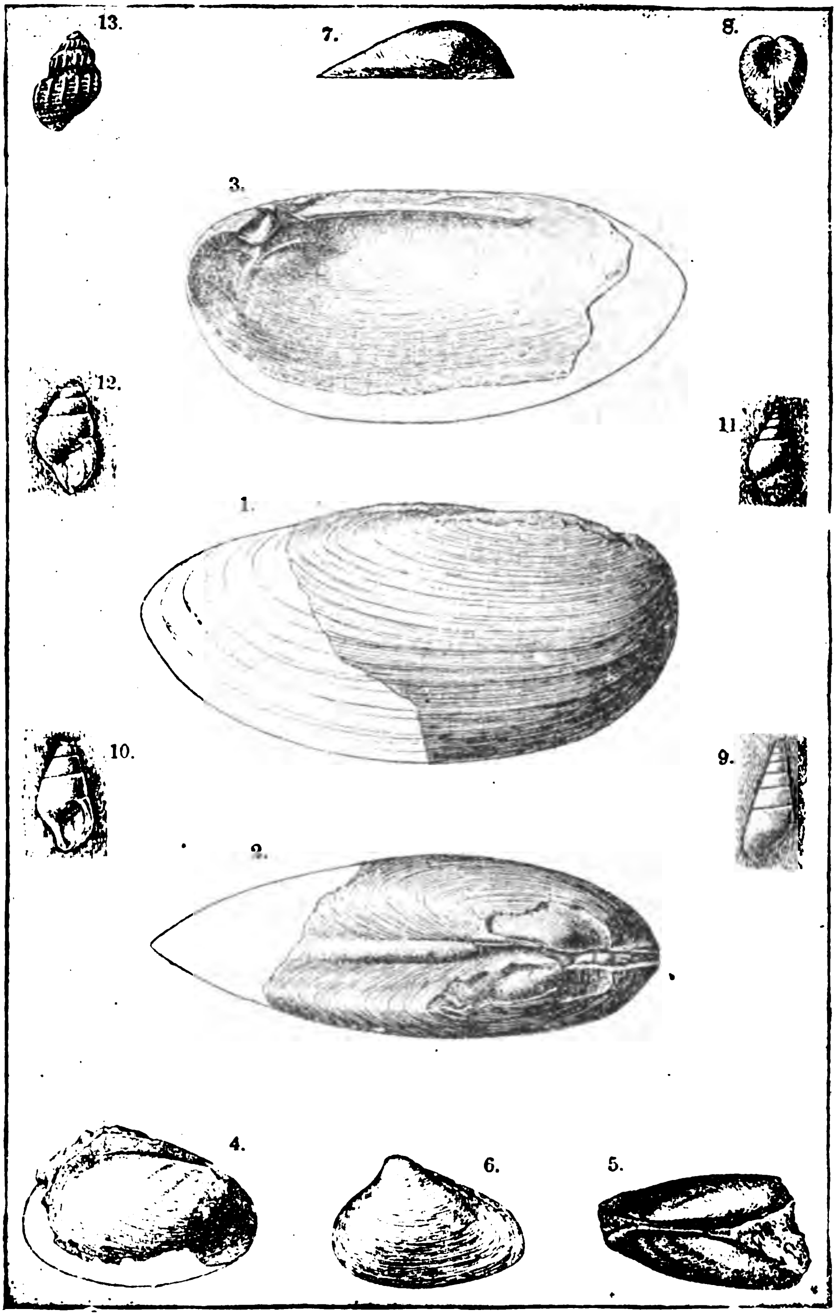
Viviparus hicksii

Fig. 11. Side view of an artificial cast of a natural mold.
Fig. 12. Side view of another similar cast.

Pyrgulifera meekii

Fig. 13. Side view of an artificial cast of a natural mold.

All the figures on this plate are of natural size except fig. 9, which is slightly enlarged.—White.



FOSSIL SHELLS OF THE DAKOTA CRETACEOUS.—AFTER WHITE

Fig. 55.—Benton limestone (formerly called Niobrara) on Coon creek looking north near the Soldiers' Home, Milford, Neb. Chalk rock full of fossil oysters (Ostrea and Inoceramus) resting on dark shale. Photograph by N. H. Darton, United States Geological Survey.

THE BENTON FORMATION

The Benton, like the other formations already described, is so concealed by drift and loess that many people are unaware of its existence, and yet it can be traced the length of the Republican river from central Red Willow county, eastward to Thayer and Jefferson, thence northward in widely distant exposures to Dakota county, thence westward along the Missouri to central Boyd county; a total distance exceeding four hundred miles.

It consists essentially of two strikingly different layers, easily recognized when once known; a black layer of shale, and a white or buff over-lying layer of chalk rock, correlated with the greenhorn limestone of the Rocky mountains. This chalky layer has been incorrectly called the Niobrara formation, as Darton finds.

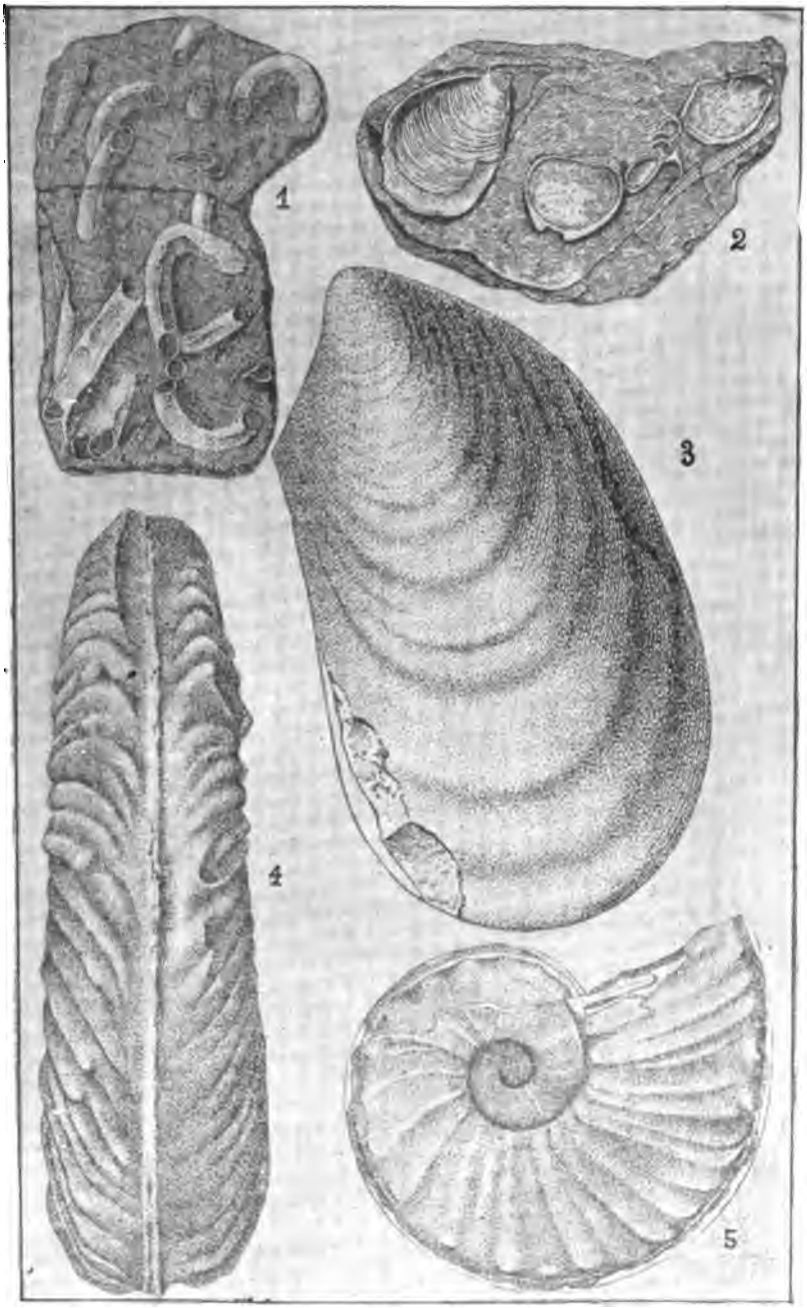
There are numerous quarries only a few miles distant from Hebron, and many buildings are constructed of the chalk rock. Around Fairbury, in Jefferson county, several quarries and lime kilns are in operation, making use of this limestone. At Milford, under the bridge by the Soldiers' Home, the white and black layers are clearly shown, and may be traced for some rods along the creek.

The next important exposures occur along the Missouri front in the northeastern counties, where the Benton limestone is again put to use for building purposes with satisfactory results. Though soft, it looks well and lasts surprisingly well, whether used alone or combined with brick or with building stone of some contrasting color. See fig. 140.

When taken fresh from the quarry it is so soft that, ac-

EXPLANATION OF PLATE V

Fig. 1. Serpula tenuicarinata M. and H.
Fig. 2. Ostrea congesta Conrad, three small lower valves attached to the shell of a large Inoceramus (after Meek).
Fig. 3. Inoceramus labiatus Schloth, right valve elongated specimen (after Meek).
Fig. 4. Prionocyclus Wyomingensis (Meek) peripheral view.
Fig. 5. Same, side view.



FOSSILS CHARACTERISTIC OF THE BENTON LIMESTONE

cording to common practice, they saw it into blocks. Subsequently it grows hard, and is laid up with mortar in the usual way. We have seen churches, residences, and business blocks built of this chalk rock, which, although built twenty or twenty-five years ago, show little change. In Kansas the chalk rock is sawed into building stones, etc., but more noticeably into fence posts for wire fences, hitching posts, lamp posts, etc., thus making it serve useful ends where lumber is high priced. It is not improbable that the selfsame "post" layer may be traced to Nebraska and put to use in an equally advantageous manner. Just across the line at Yankton, S. D., the Benton furnishes material for the manufacture of hydraulic cement, which is being put to steadily increasing use, and is in demand over the whole country. The chalk rock is simply mixed with a certain proportion of the accompanying shale and roasted. It is an important industry of that state, and a large number of men are employed and a natural resource developed.

South of us, in Kansas, great progress is being made in the manufacture of hydraulic cement, and the industry is being pushed to the front, while our cement resources lie untouched and undeveloped.

The thickness of the Benton is 150 to 200 feet, allowing 100 to 150 for the dark, shaly portion, and 50 to 75 for the chalk rock. There are no exposures to enable one to judge correctly, and well records furnish meager information.

These beds are readily distinguished from the preceding and succeeding formations by means of their fossil oysters, *Ostrea* and *Inoceramus*. One of these oysters, *Ostrea congesta*, is about the size of one's thumb; the other, *Inoceramus labiatus*, is about as large as the oyster of the present day. They occur in great masses in extensive beds.

NIOBRARA FORMATION

The Niobrara zone lies a short distance west of the Benton, but is covered with Pleistocene deposits. It outcrops

extensively in the Republican valley as far west as Cambridge. Heretofore the chalky layer of the Benton has been called Niobrara. It seems to be the most illy-defined formation in the state, and its limits are yet to be determined. It consists of shales and chalky limestones.

THE PIERRE FORMATION

The Pierre formation, so named after Pierre, S. D., where it is so broadly exposed, is commonly spoken of as the Pierre shales, because consisting wholly of various shales, mostly very dark. In places it is called by the people the gumbo, because when wet it rolls up on the wagon wheels as any gumbo or clay soil is apt to do. It consists of a variety of shales, mostly of a dark color, and underlies the entire state west of Seward county, increasing in thickness from several hundred feet at York, to 900 feet at Dannebrog, 1,100 feet at Hastings, 2,500 feet at Kearney, probably 3,000 at North Platte, and 3,500 to 4,000 feet under the western tier of counties; and thence the thickness increases steadily to the westward, and reaches the astonishing thickness of 7,000 feet in the Denver basin.

Great as is the mass of Pierre, it is destitute of value to a community, for it contains no stone, no building material, no water. If a little water is struck, it is apt to be unfit for use for house, stock, or steam boilers. This works serious hardships in northwestern Nebraska, but more especially in South Dakota and Wyoming. In these regions it is a great problem where and how to get water. Many deep wells have been sunk, at great expense and without results. Some of the towns and stations near the Bad Lands have no water, save what is brought on the water cars.

Besides being too thick to penetrate with ordinary drilling, the Pierre "shells-in" badly, making it necessary at frequent intervals to cast the drill hole solid with Portland cement, let it set, then drill through it. This repeated often enough enables the well digger to drill deep into it, but it is slow and costly and yields no results. Though attempts are

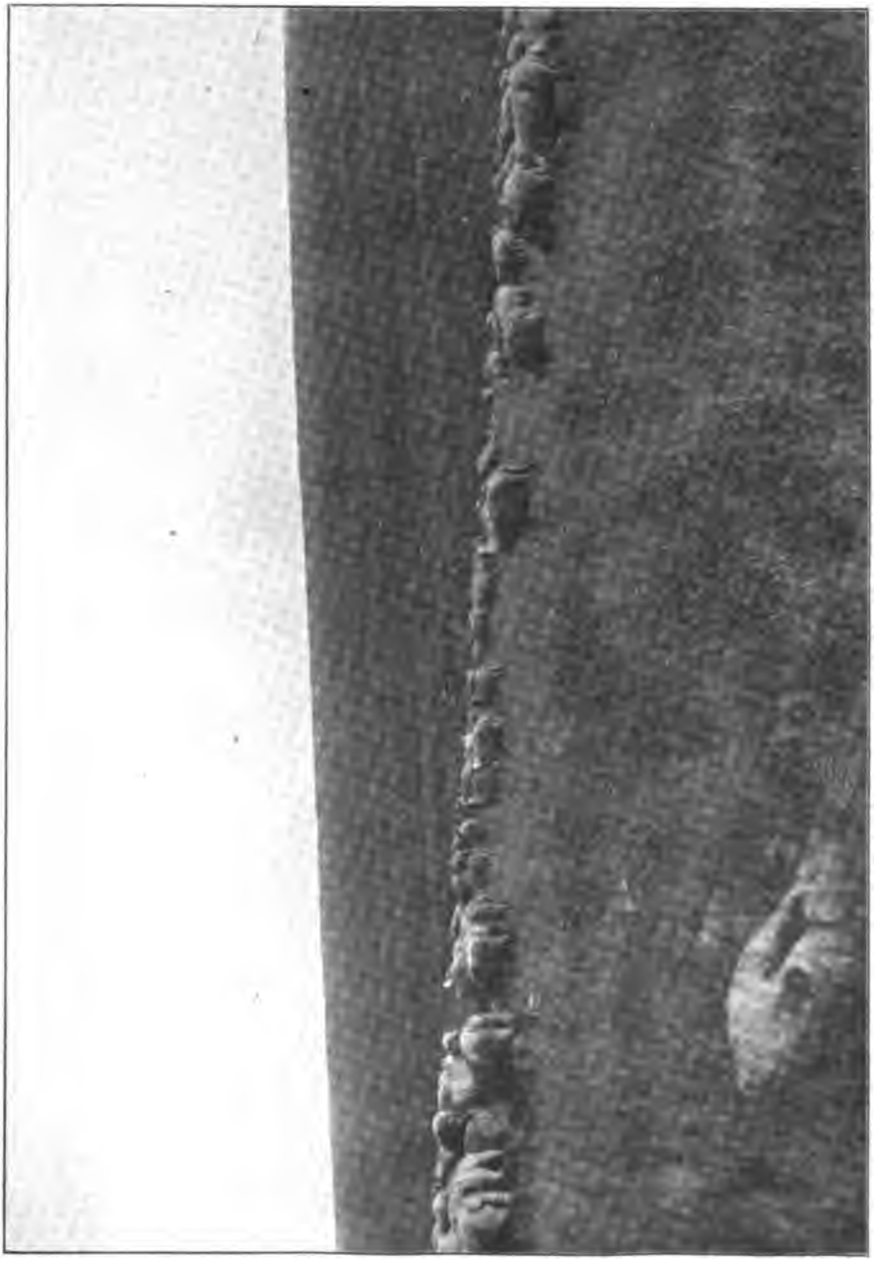


Fig. 56.—Typical rolling gumbo, or Pierre prairie such as extends from northern Nebraska into South Dakota, with a herd of 2,600 sheep. Grazing the very best, but water lacking.

still being made to pierce the shale in our western counties, it has not been done, and citizens are advised of the inutility and wastefulness of the undertaking. A drill hole one mile deep or thereabouts costs a moderate fortune.

The Pierre sustains a good crop for grazing, but thousands of square miles of it in neighboring states are destitute of water for herds, save as dams are built and surface water caught.

Fig. 57.—Portion of a great herd of range cattle on a gumbo flat (Pierre shale), with hills of Pierre in the distance, such as may be found extending from northern Nebraska into South Dakota. Excellent grazing.

The exposures in any one place in Nebraska are small, for the Pierre is deeply covered with other material, save a narrow strip along the Republican river, the Missouri and

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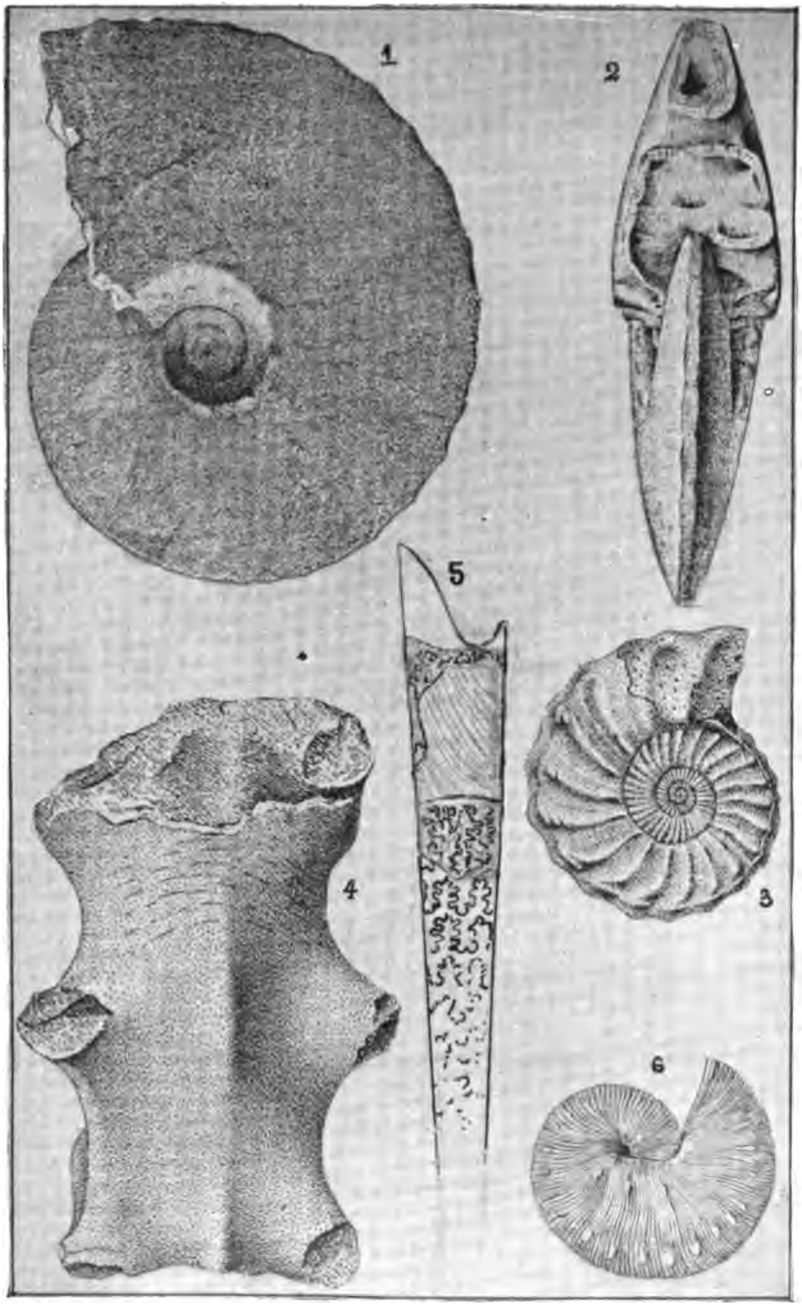
EXPLANATION OF PLATE VI

Fig. 1. Placenticeras placenta DeKay, side view.
Fig. 2. Same, edge view.
Fig. 3. Prionotropis woolgari Mantell, side view.
Fig. 4. Same peripheral or edge view.
Fig. 5. Baculites or cane shell, commonly called petrified fish.
Fig. 6. Scaphites nodosus.



FOSSILS CHARACTERISTIC OF THE PIERRE SHALE

Niobrara, and the northern Pine Ridge country. It is often of importance to ranchmen and others to recognize this shale, and about the best general guide is its dark color. The Tertiary beds above the Pierre are noticeably light in color. West of Kearney, if one digs through the light Tertiary rocks and comes upon dark shales, he can be reasonably sure it is Pierre, and should at once abandon drilling.

Though poor in other things, the Pierre is rich in fossils, which are characteristic. A few of the very commonest will be figured to assist citizens in determining the beds.

Fig. 58.—A "pine apple" concretion of the septarium variety, common in the Pierre shale, sometimes 3 to 4 feet in diameter.

Fig. 59.—Same, with some of the clay blocks removed, showing the calcite partitions.

THE LARAMIE FORMATION

The Laramie, as recently described by C. A. Fisher, enters Nebraska from Wyoming, and covers a few acres along a creek in western Scotts Bluff county. It doubtless extends for some distance under the county, but is unimportant save to geologists and teachers, and needs no further mention at this time than that it marks the close of Cretaceous times and Cretaceous deposits in Nebraska, the Pierre being the last extensive bed, and ushers in an entirely new order of beds and conditions.

THE OLIGOCENE

The Oligocene or Bad Lands, coming next in point of time, lies unconformably upon the black Pierre shale, and is gen-

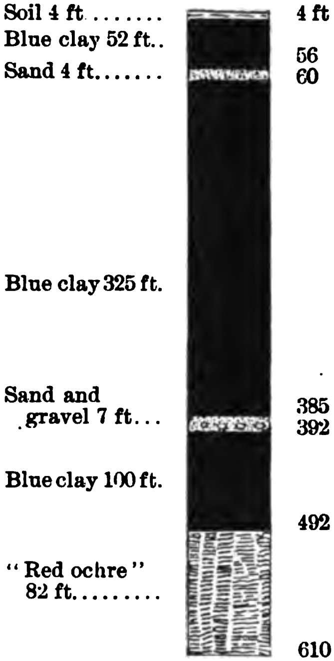


Fig. 60.—Record of boring at Seward, Neb.—Darton.

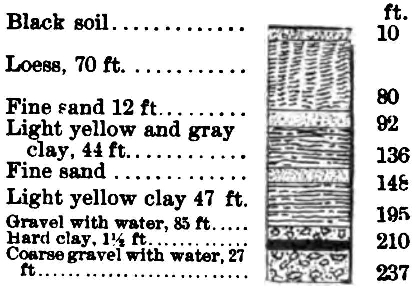


Fig. 61.—Record of deep well at Fairmont.

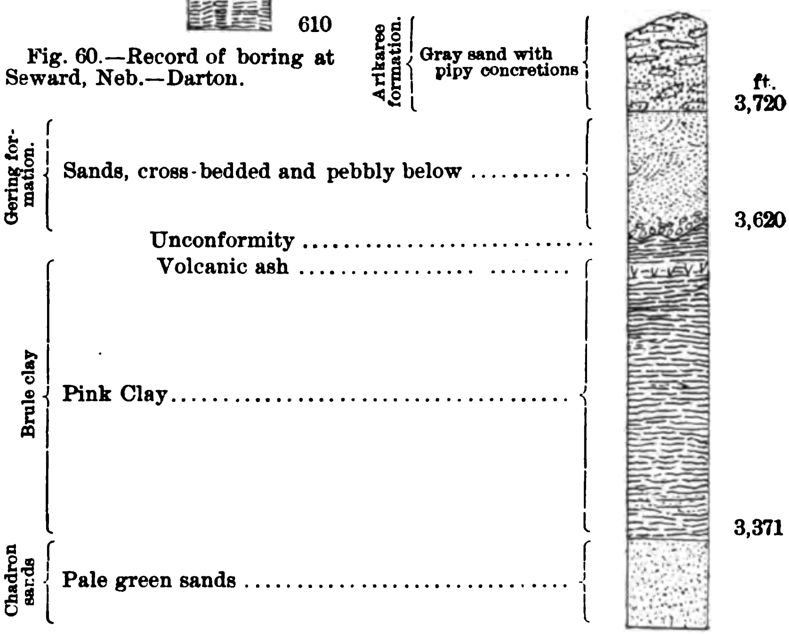


Fig. 62.—Section at Chadron, Neb.—Darton.

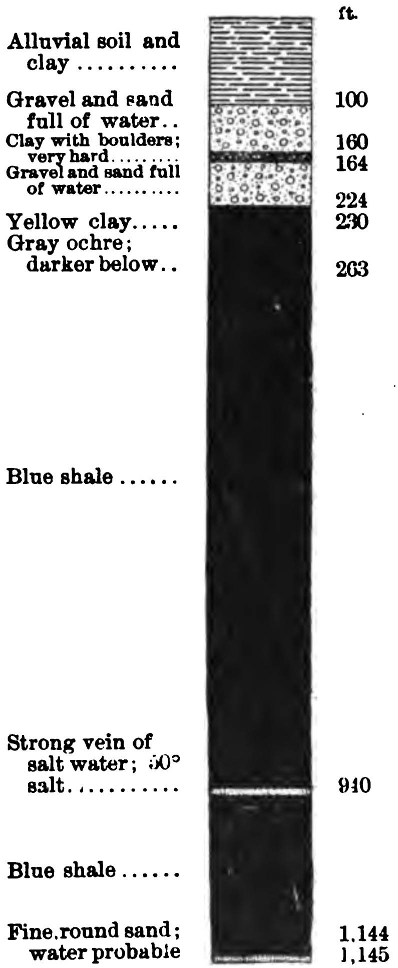


Fig. 63.—Record of deep boring at Hastings, Neb.—Darton.

Fig. 64.—Record of deep boring at Dannebrog, Howard county, Neb. Cretaceous shales represented in black.—Darton.

erally known throughout the state, and for that matter throughout the world, as the most famous fossil field. The Bad Lands are made up mainly of light colored clays and some sand, varying in thickness from 600 to 800 feet. These beds yield little or no water, and that of poor quality, and furnish no building materials as far as known. Their economic importance consists then mainly in the fossils found there, which are universally prized, and often command high prices, a number of people being engaged in digging and collecting them for eastern museums and curio dealers.

Surrounding the Bad Lands are valuable grazing lands, and herds find shelter in the recesses and deep cuts, so they serve an economic purpose in protecting range cattle. The name Bad Lands is a misnomer, the lands not being bad in the sense of sterile, but bad in the sense of hard to traverse, as the original French expression shows, *"Mauvaises terres á traverser."*

The Bad Lands are rather well elevated, standing at a height of about 3,500 feet, and are in the right position to wash excessively. Where the wash is not excessive they soon become good lands, producing crops and valuable grasses. They are entirely of fresh water origin, unlike the other described formations, which are mostly marine.

A great fresh-water lake, or sea as it should be called, covered the western part of South Dakota and parts of Colorado and Wyoming. This lake was filled with Tertiary mud to a depth of about one thousand feet in the backbone of the Big Bad Lands of South Dakota. Drainage has carved the Bad Lands in a style of magnificent grandeur. Many tourists, finding these lands accessible since the B. & M. and the F., E. & M. V. railroads have extended their lines into the Black Hills, visit these places from the nearest stations, thus giving employment to a considerable number of guides, teamsters, and hotel keepers during the summer months.

The fossils of the Bad Lands, though of such fundamental importance to scientists, can not even be hinted at here, further than to figure a few for those interested, and to say

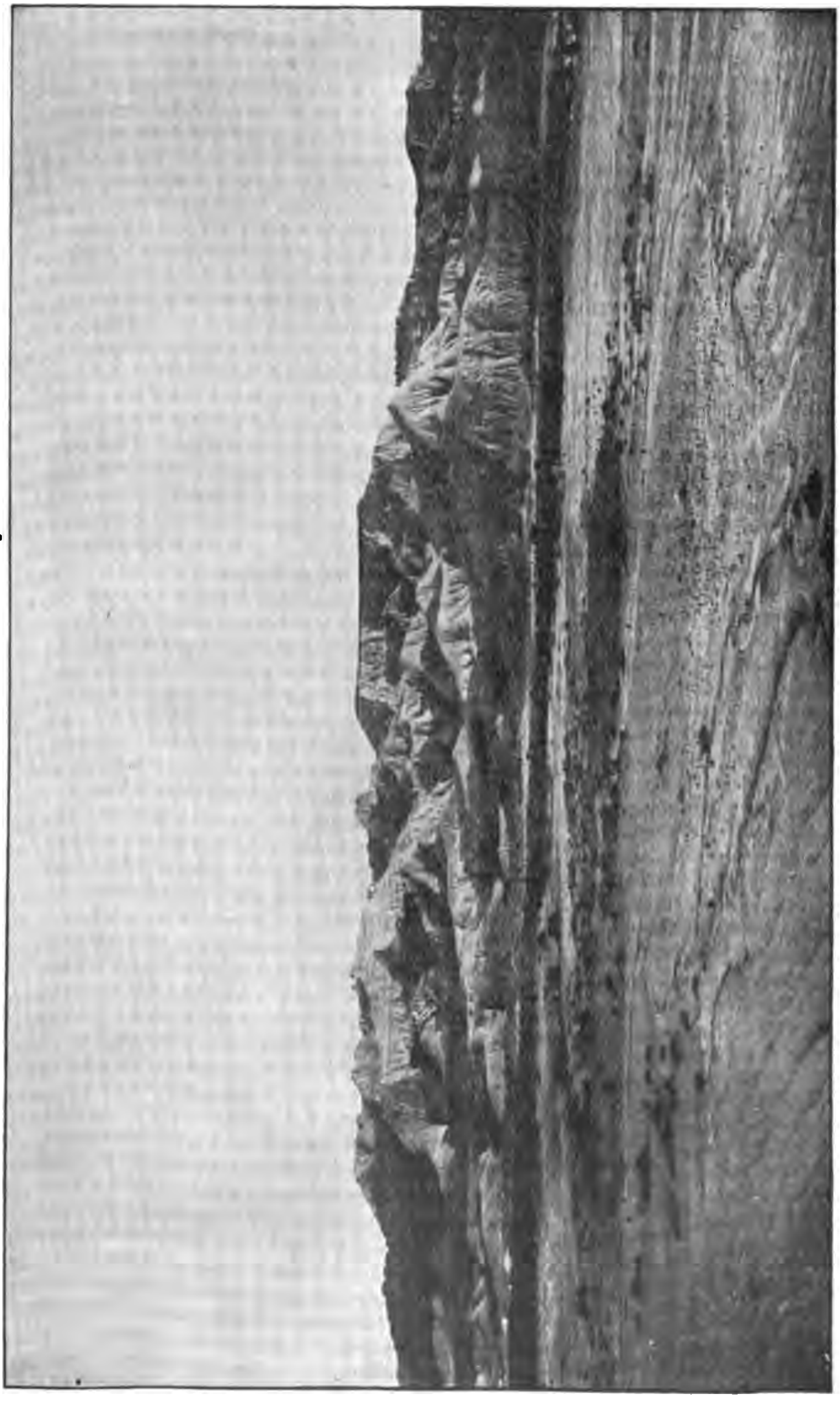


Fig. 65.—Bad Lands of Brule formation (Oligocene) 2½ miles west of the Burlington & Missouri station at Adelia, Sioux county, Neb., looking northwest. Photograph, Morrill Geological Expedition, 1895.

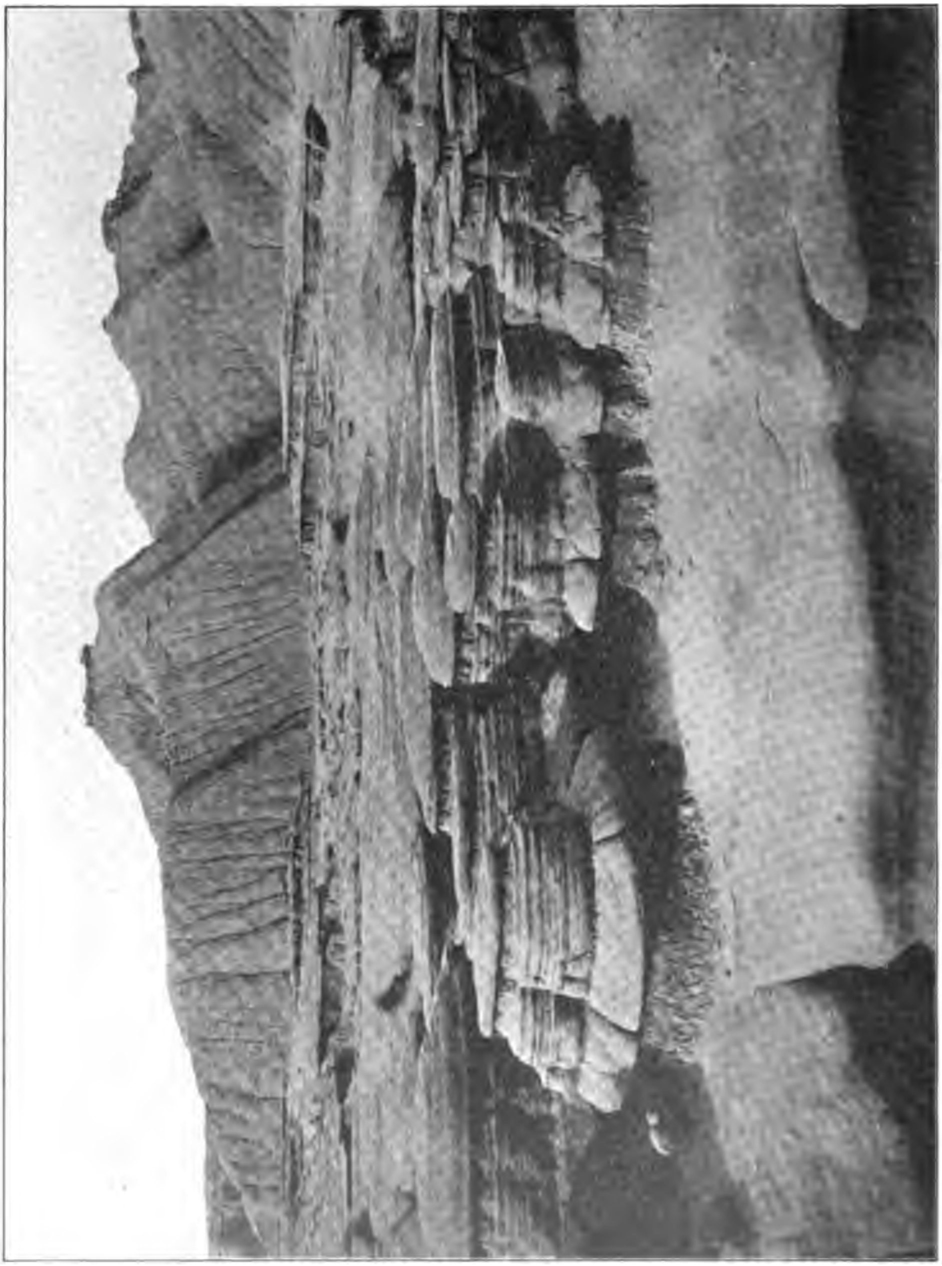


Fig. 66.—Toadstool park, Sioux county Bad Lands, two miles west of Adelia on the Burlington & Missouri River railroad. Photograph, Morrill Geological Expedition of 1895.

Fig. 67.—The culmination of the Nebraska Bad Lands as seen near the state line in South Dakota. These are the Big Bad Lands known locally as the "good bad lands." 60 to 80 miles north of Gordon on the Fremont, Elkhorn & Missouri Valley railroad. Scenes of extraordinary interest to all tourists. Photograph, Morrill Geological Expedition 1895.

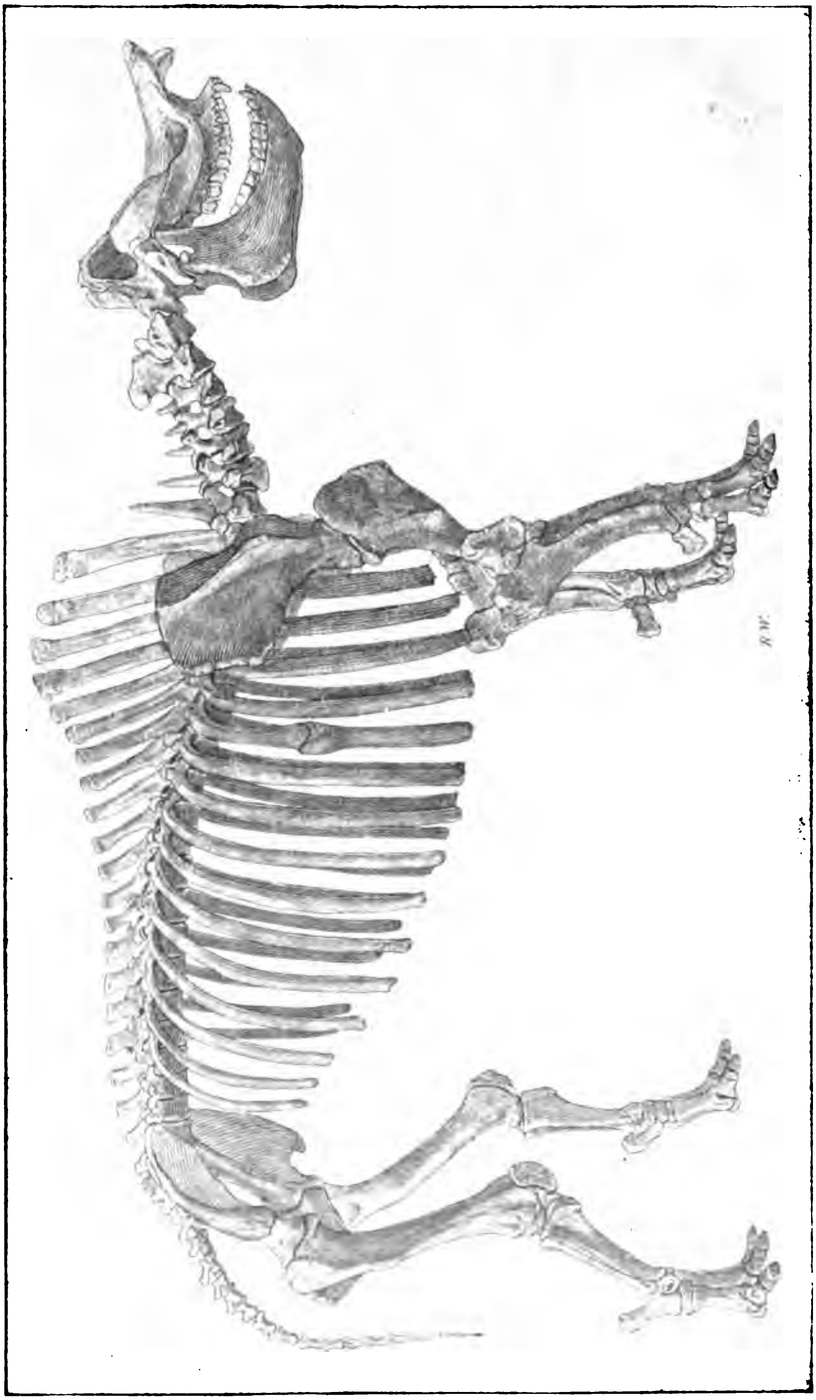


Fig. 68.—Titanotherium robustum, one twenty-third (1/23) natural size. Found in the Sioux county Bad Lands.—Restored by Osborn.

that they represent a high order of animals, such as lions, wild dogs, tapirs, camel, rhinoceros, horse, monkey, etc.

TEETH OF A FEW BAD LAND MAMMALS

Fig. 69. Aceratherium mite (Rhinoceros) upper jaw, showing immature dentition (x½).

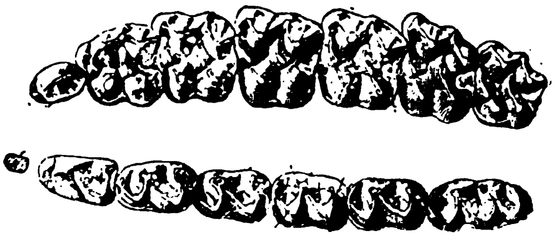


Fig. 70. Mesohippus bairdi, (three-toed horse) upper and lower jaw, natural size.

Fig. 71. Colodon dakotensis (tapir) molar and premolar series, internal and crown views.

It may prove profitable and expedient at another time to give these the prominence they deserve, for the fossils of our Bad Lands have taught some of the most fundamental lessons known to the zoologist.

The lava beds so often reported in the Bad Lands are readily accounted for. It is a common thing to find the Bad Lands intersected by dikes of clay and chalcedony; the last named is so hard that weather has no appreciable effect upon it. Being dark and ragged looking, and being scattered over the fields like lava, it is easily mistaken for it.

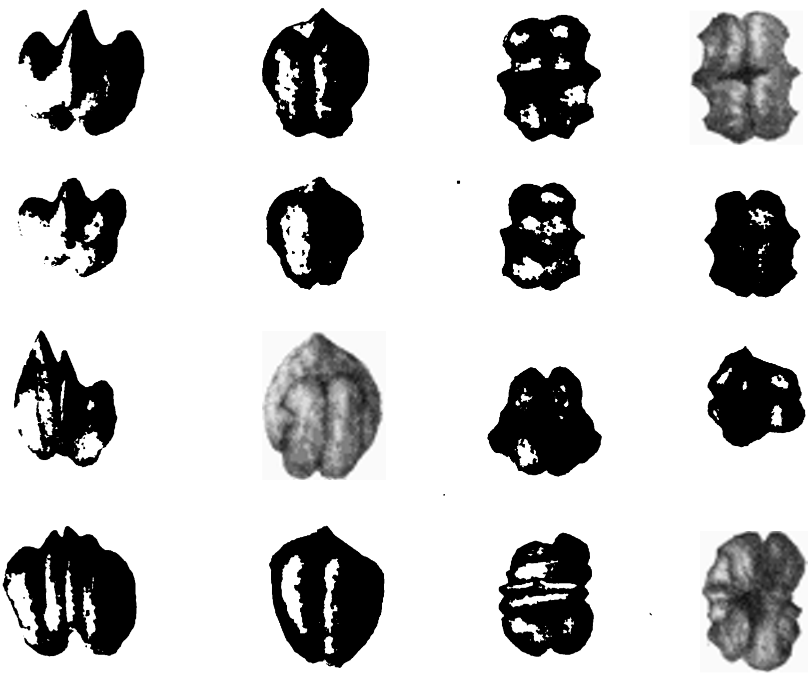


Fig. 72. A group of chalcedony nuts, archihicoria siouxensis, showing in the four vertical columns four different aspects of each. Column 1 (to the left), front view of the embryo; 2, side view; 3, top view; 4, bottom view. Apparently the double part is the normal condition of all.

ARIKAREE FORMATION

It might convey the idea more directly to many minds to call this the Butte formation, for the buttes of western Nebraska have been carved out of it. It lies directly upon the Bad Lands, and might readily be mistaken for them. However, the Bad Lands are mainly clay, with yellowish or pink-

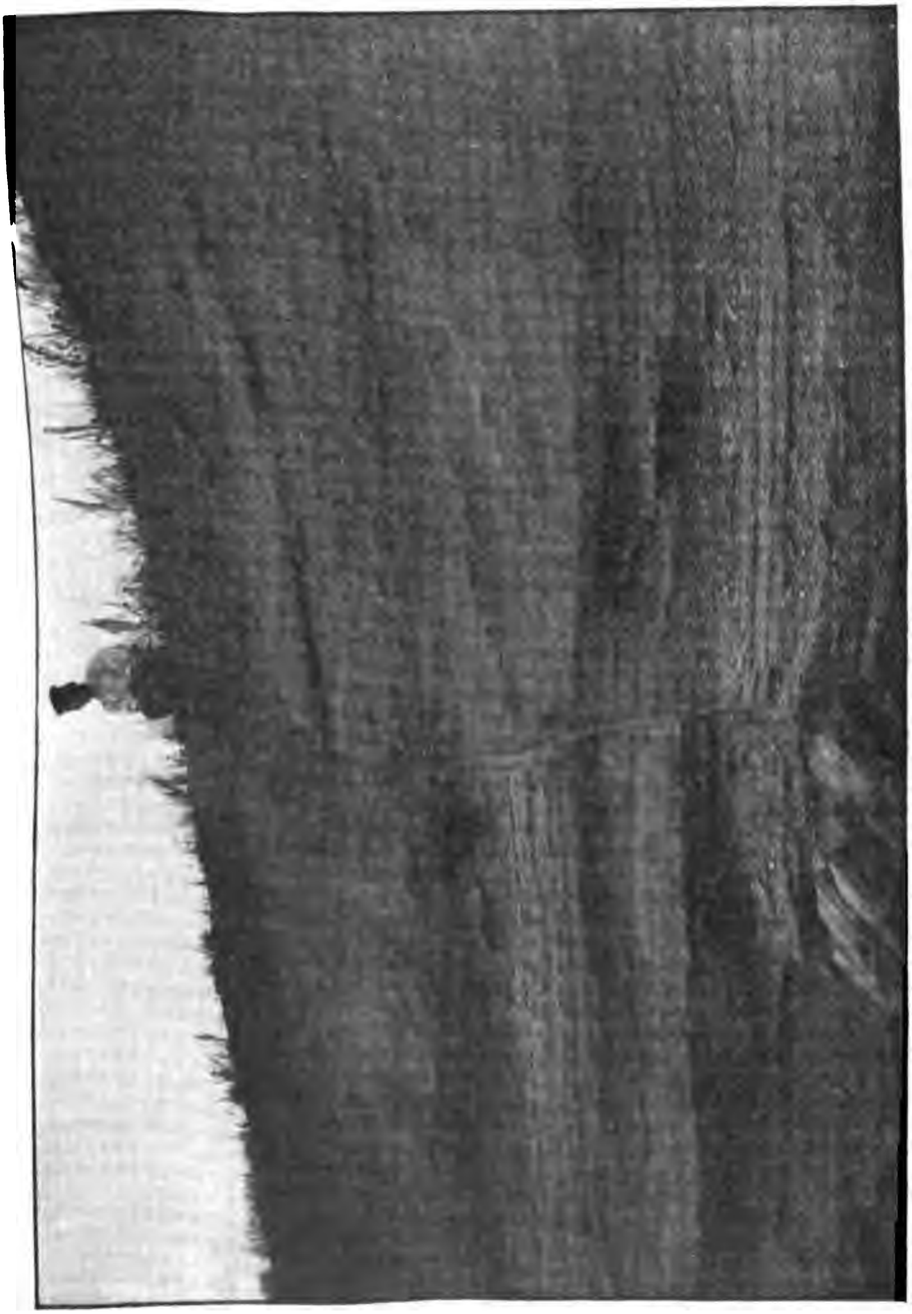


Fig. 73.—Gering formation (Miocene) with fault. Burlington & Missouri River railroad cut one-half mile south of Rutland siding, Dawes county, Neb. Displacement about three feet.—Darton.

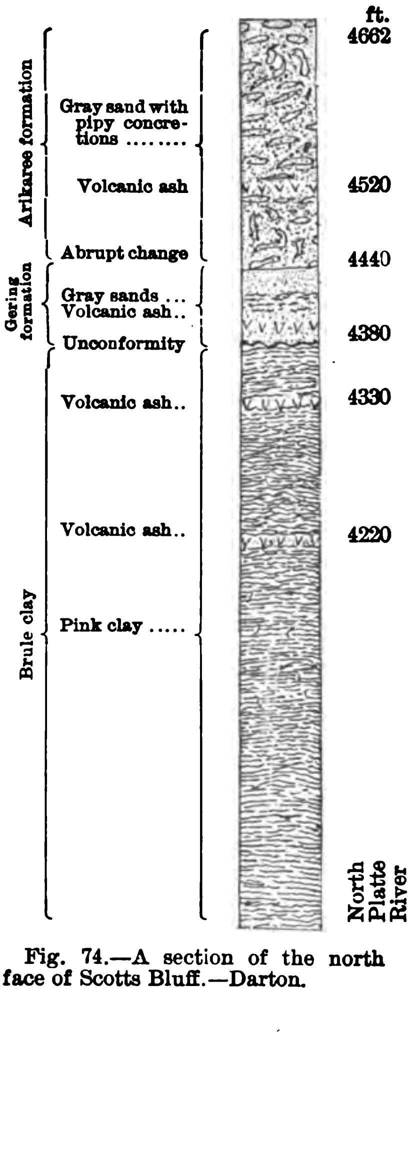


Fig. 74.—A section of the north face of Scotts Bluff.—Darton.

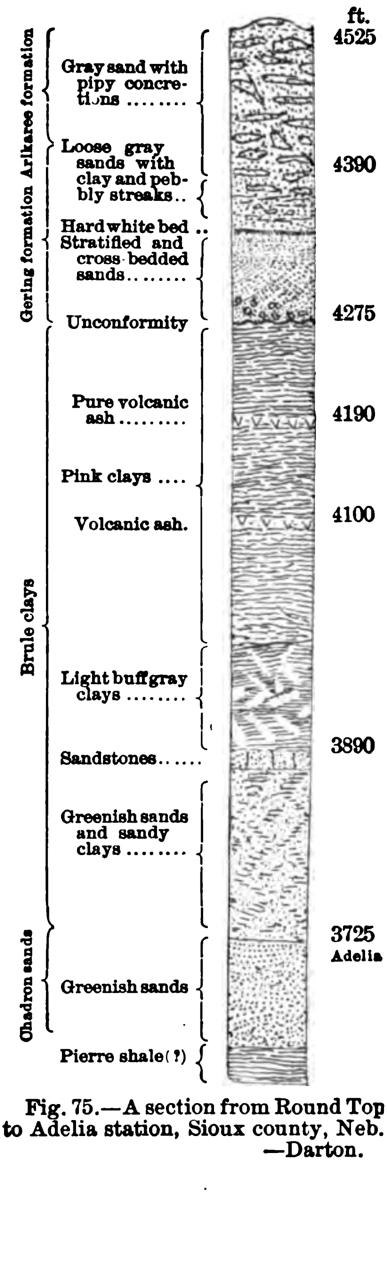


Fig. 75.—A section from Round Top to Adelia station, Sioux county, Neb. —Darton.

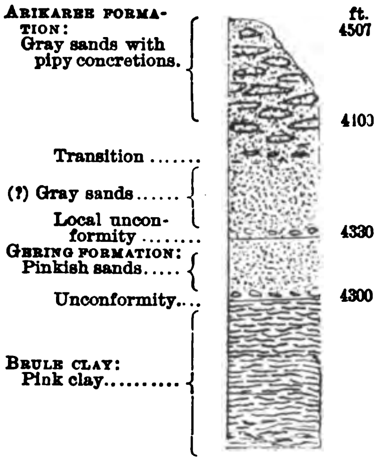


Fig. 76.—Vertical section at Sheep mountain, Banner county, Neb.

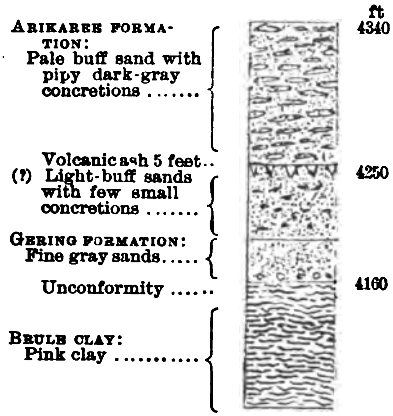


Fig. 77.—Section at Redington gap, Cheyenne county, Neb.

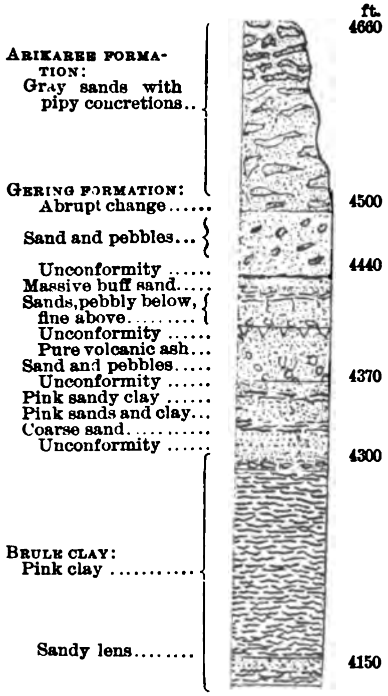


Fig. 78.—Section of Gering and associated formations 6 miles south-southwest of Gering, Neb,

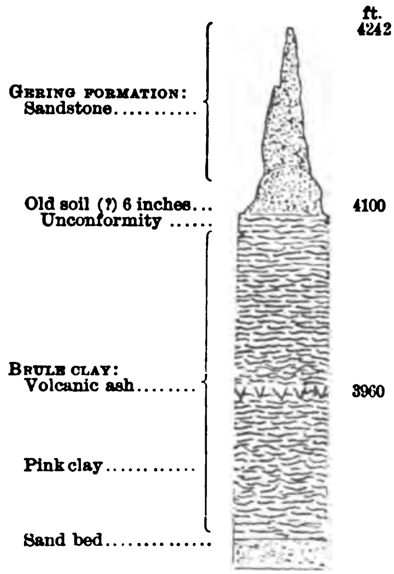


Fig. 79.—Section at Chimney Rock, Cheyenne county, Neb.—Darton.

Fig. 80.—Vertical section at Courthouse Rock, Cheyenne county, Neb.

Fig. 81.—Vertical section 8 miles due south of Gering, Neb.

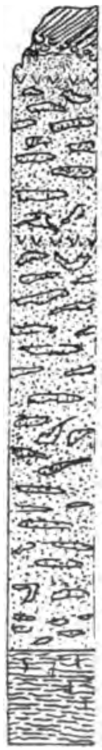
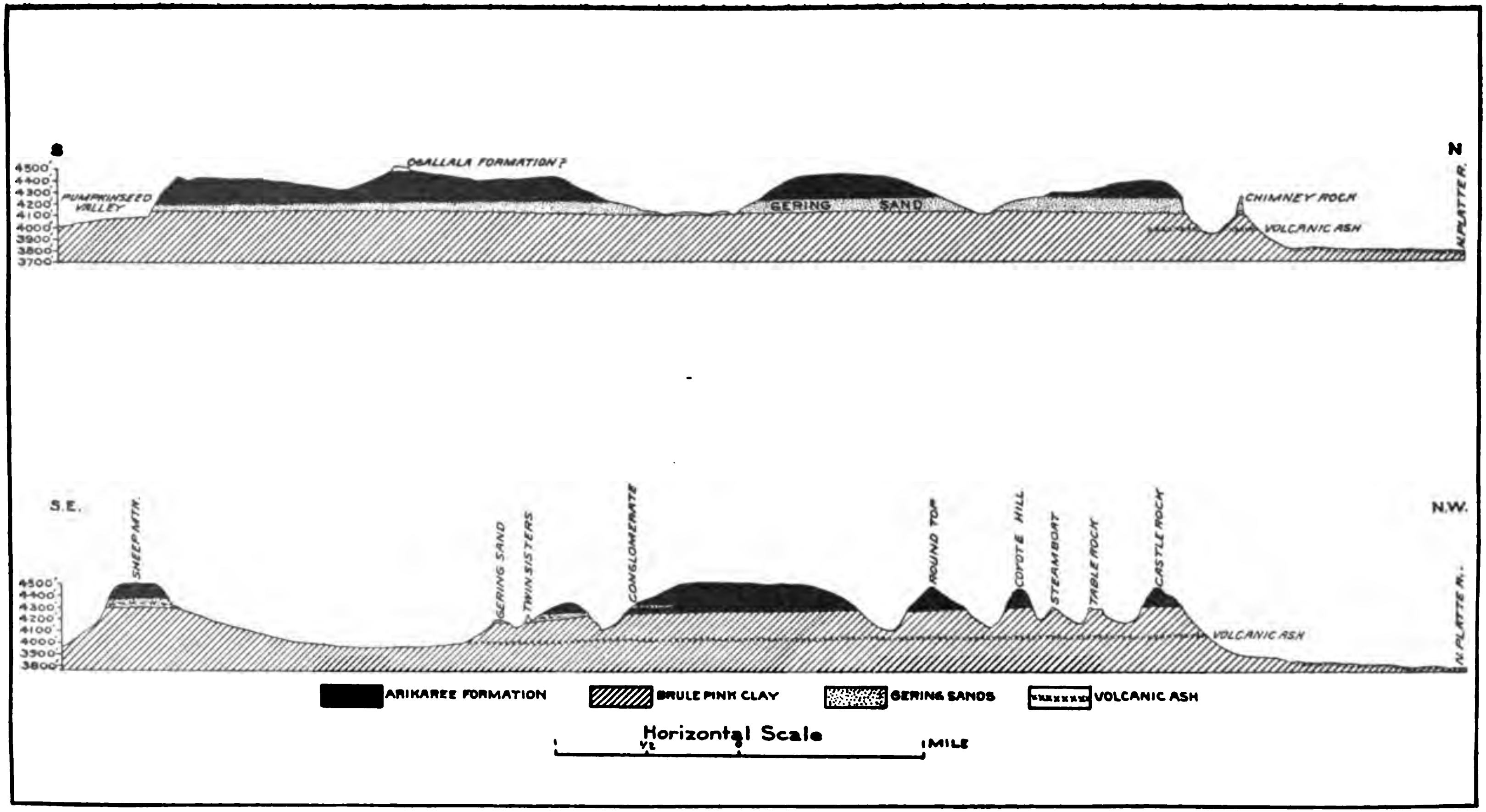


Fig. 82.—Columnar section of formations exposed in Wild Cat mountains and vicinity, Banner county, Neb.—Darton.

Fig. 83.—Vertical section at Bird Cage Gap, Cheyenne county, Neb.—Darton.



Figs. 84, 85.—Cross-sections showing relations of formations near Chimney Rock and Horseshoe Flat, Neb.—Darton.

Fig. 86.—North face of Pine Ridge at Warbonnet canyon looking north across the Hat Creek basin toward the Black Hills outlined in the distance. Pine covered cliffs are Arikaree formation. The white patch in the distance is the Brule clay of the Little Bad Lands, Sioux county, Neb. Beyond the Brule clay the Pierre formation begins. Photograph, Morrill Geological Expedition, 1895.

ish colors predominating, while the Arikaree is sand of an ash-gray or buff color. A further means of detecting it may be cited in the pine trees which find congenial ground for growth upon it.

The *Pinus ponderosa* follows the Arikaree along the western tier of counties north to Pine Ridge in Sioux county, and northward along the northern tier of counties as far east, at least, as Long Pine. Its presence is indicative of the Arikaree, which formation is best exposed along the steep wall of

Fig. 87.—Five Point buttes, Arikaree formation, Sioux county, Neb., covered with western pines, *Pinus ponderosa*. The broad alluvial slope is covered with buffalo grass and grama grass. The beginning of the Bad Land clays is marked by the coarse bunch grass and yuccas in the foreground.

Pine Ridge, in Sioux county, facing the Hat Creek Bad Lands. Here it is 500 feet in thickness with little evidence of stratification, save near the top, where there is a clearly marked division, separated by a one-foot bed of flint, north of Harrison, which may be called the Harrison flint. There is a suspicion, from the nature of the material above the flint, that it is the top of the Arikaree, and that the portion above is Ogallala. It is called by some a wind-deposited

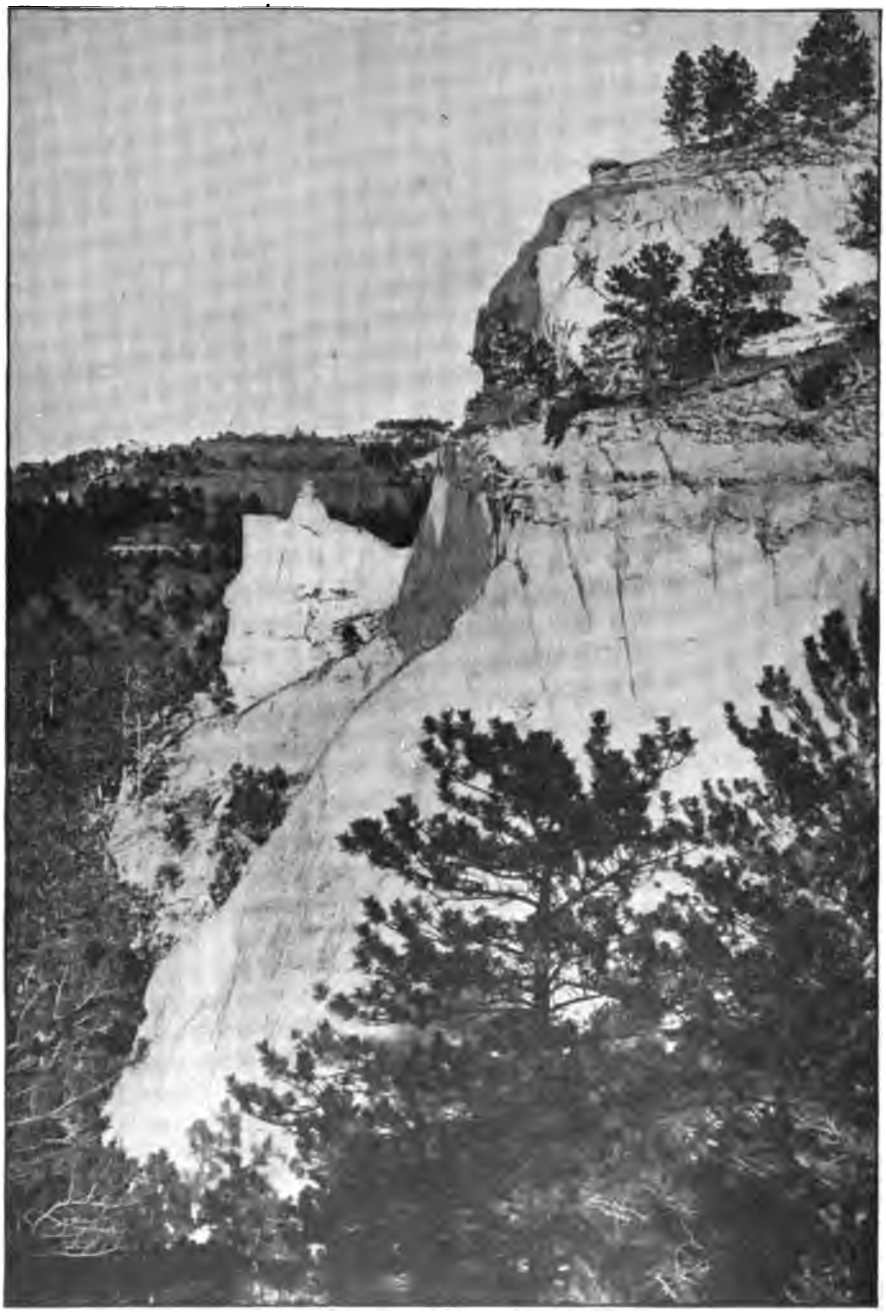


Fig. 88.—Cliffs of Arikaree formation, north face of Pine Ridge near Monroe canyon, Sioux county, Neb. Photograph, Morrill Geological Expedition, 1895.

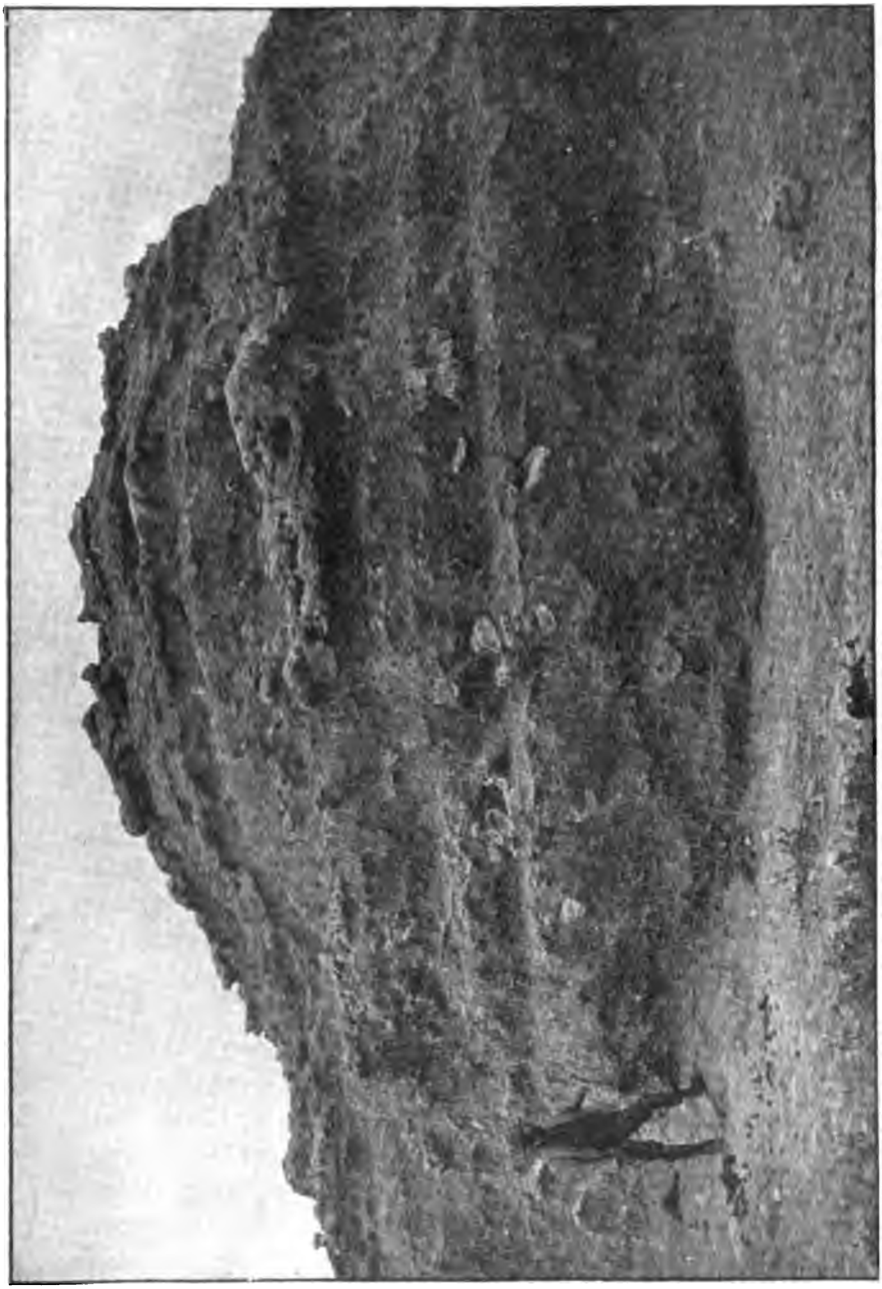


Fig. 89.—Daimonelix beds in Arikaree formation at head of Little Monroe canyon, Sioux county, Neb. Photograph by N. H. Darton, United States Geological Survey.

bed, though generally considered to be of aqueous origin. Such young rocks are not consolidated, so this formation yields little of economic importance, outside of good water, which is only procured at a considerable depth; occasional beds of volcanic ash, which has a limited market as yet; and the forests of pine trees. At the summit also occur the well-known fossil Corkscrew beds, together with masses of fibers and rootlets. This fibrous structure is so constant in the formation that it may be used as a means of identification.

The Arikaree may be detected also by its masses of concretions and concretionary pipes which project from some of the walls like guns from a fort.

Figs. 90–97 inclusive.—A few forms of the fossil corkscrew, Daimonelix, characteristic of the Arikaree formation of Pine Ridge, Sioux county, Nebraska. Height, 6 to 8 feet. Drawn from specimens in the collection of Hon. Charles H. Morrill.

An item of considerable promise economically is found in the utilization of the springs issuing from the line of contact between the Arikaree and the impermeable underlying Bad Land clays. This seep is turned to account for irrigation along the alluvial slope at the base of the Pine Ridge wall, and many important springs and streams, particularly in the northern tier of counties, are supplied from the sand of this formation, which catches and holds practically all the rainfall, and delivers it to feed streams and springs.

Its fossils do not differ materially from many of those found in the Bad Lands and for the present purposes need not be figured here.

THE OGALLALA FORMATION

The Ogallala formation, so named by Darton because of typical exposures occurring around the town of Ogallala, in Keith county, might be better known to the people under the name "magnesia." It is called magnesia in Kansas and Nebraska. It is also called Tertiary grit and "the mortar beds" in Kansas.

It is essentially a limestone with impurities, ranging in color from light gray to nearly white. It is a calcareous grit with a calcareous cement, often containing pebbly conglomerate and beds of Rocky mountain sand and ledges of fairly compact sandstone. At the base of the irregular cliffs of the calcareous magnesia, it seems to break down into a peculiar irregular lime gravel. On flat tables of magnesia, the soil changes insensibly into magnesian gravel and then into the unaltered magnesia. It breaks down into soil easily and is productive.

Just how far east one can trace the Ogallala is not safe to assert until the stratigraphy of the state can be studied more in detail. However, interesting quartzite rocks in Franklin county are related to the Ogallala. These green quartzite are known at Woodruff, Kan., and in Franklin, northeastern Rock, and Knox counties, Nebraska. These quartzites are economically of some importance, being of an attractive green color, fine texture, and of the most lasting quality. The county jail at Franklin, and other buildings, foundations, and bridges are built of this rock, which probably ranks as the densest, strongest, and most beautiful stone in any formation in Nebraska, though as yet it is the least used. The B. & M. railroad is beginning to use large amounts of it for ballast, and some of the alleys and crossings in Lincoln are paved with this rock, which wears like granite.

At Verdigris, apparently the same stone occurs again, and is used in the flouring mill, in the construction of dams, foundations, etc. Though a beautiful and lasting stone, it seems to occur in rather restricted areas in Nebraska,

Fig. 98.—Glacial drift on crossbedded Dakota sand rock at Bennett, Neb. Photograph, Morrill Geological Expedition, 1898.

increasing in thickness and extent just across the line in Kansas. The attention of builders and architects is directed to this building stone, for it is altogether superior to many kinds of rock which are shipped long distances to use in the state.

Fig. 99.—Glacial drift near Fairbury, Neb., consisting of Sioux quartzite and granite boulders.

GLACIAL DRIFT

In point of time, the glacial drift comes next, and is probably the best known formation in the state.

It is generally known to all classes by the pink and purplish boulders of Sioux quartzite, mingled with boulder clay, usually of a reddish buff color, which merges into the overlying loess or "yellow clay." The characteristic Sioux quartzite, pebbles, and boulders are derived from the beds of quartzite at Sioux Falls, S. D., having been transported by the ice sheet southward across the eastern end of Ne-

braska and part of Kansas. As far south as Richardson county these boulders may be found even twenty feet long by twelve feet broad and ten feet thick.

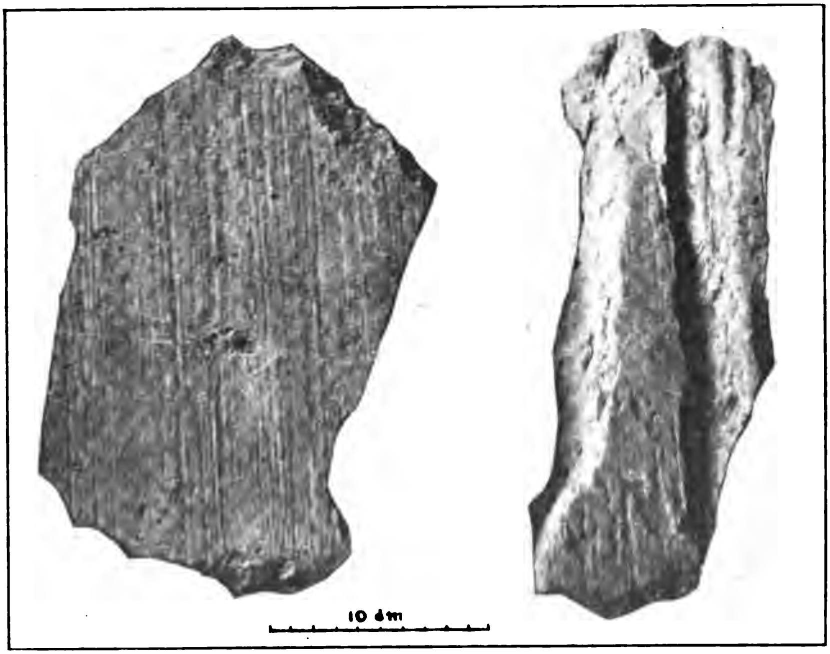
Our glacial drift belongs to the Kansan epoch, and hence is of relatively early origin, with many of the granitic rocks and the more basic rocks rotted down. West of Seward it has thinned out and is traced with difficulty. York county seems to be in the line of its extreme western limit.

Fig. 100.—A glacial boulder of Sioux quartzite about 20 feet long by 10 feet wide and 10 feet thick, after a large amount had been blasted off for building foundations in the neighborhood.

Our glacial drift is thin indeed as compared with that of Iowa, which is often more than one thousand feet, for in Nebraska, at best, it is seldom more than a foot or two. This region was the edge of the great ice cap. As the ice sheet moved irresistibly southward it naturally tended to tear down and level surfaces, and to plane, score, and scratch rock sur-

faces over which the ice was pushed. Around northern Ohio these grooves are often deep and broad, and the exposed rocks show evidence of the abrasive action of the glacier. In Nebraska this is seldom seen, chiefly because our rocks are so deeply buried.

At La Platte, the Carboniferous limestones have been planed, and still show the grooves and fine striae left by the



Figs. 101 and 102.—Carboniferous limestone at Weeping Water, Neb., planed and grooved by glacial action. Fig. 101 shows fine glacial striae, while Fig. 102 shows in addition one large groove 3 inches broad and 1 inch deep. The above museum specimens were broken from a glaciated surface exposed for about 100 yards.

ice, and at South Bend glacial grooves have been noted in the Dakota Cretaceous. The same has been reported at Iron Mound, near Wymore, and at Roca the rocks are finely scored. The best example is to be found at Weeping Water. Here the limestone was planed smooth by the ice cap, and many grooves and fine striae cut, and the whole rock surface

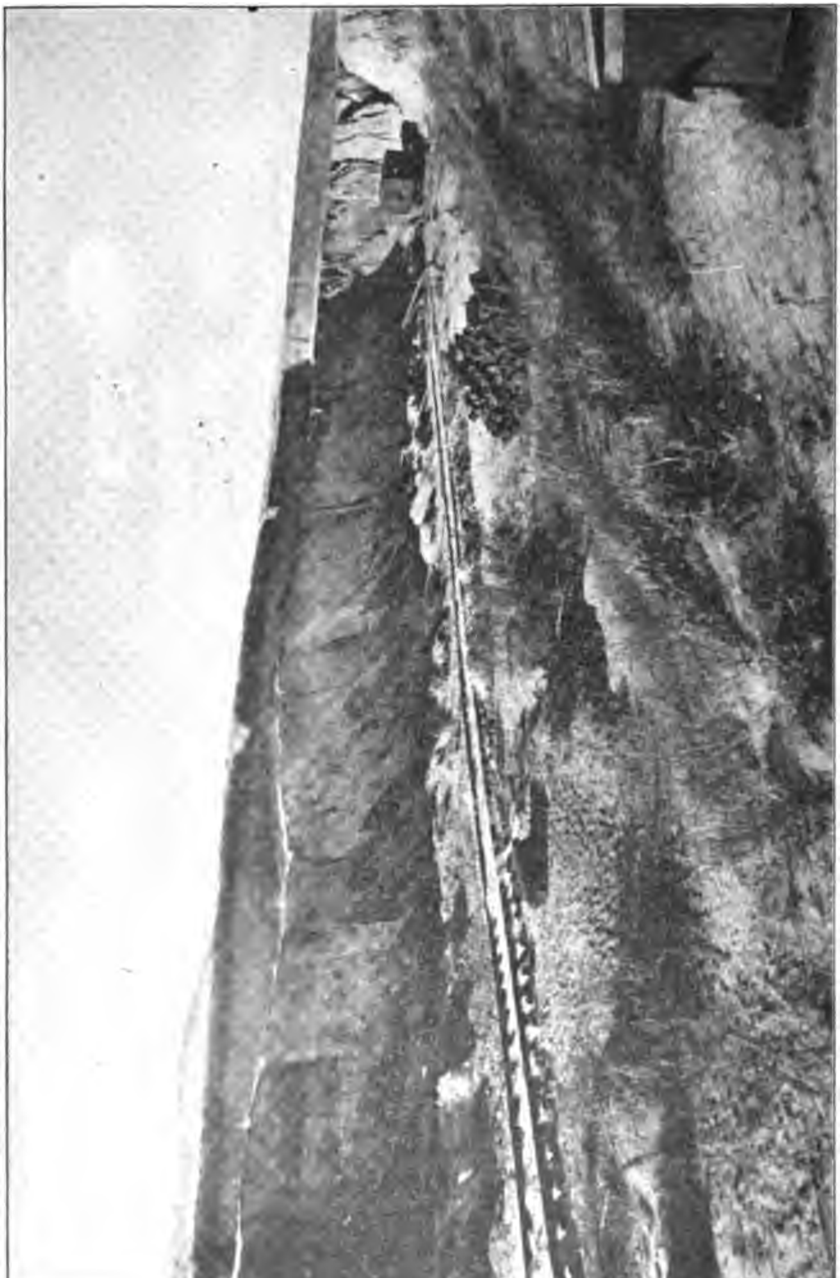


Fig. 103.—Industrial scene, the gravel pits of the Rock Island railroad near Fairbury, Neb. Gravel used extensively for ballast. This is glacial gravel overlaid with loess, the line between the two being clearly shown in the engraving at U. L, loess or yellow clay, 10 to 20 feet; D, drift gravel, 20 to 40 feet. Photograph, Morrill Geological Expedition, 1899.

reduced almost to a plane. The largest grooves noted were three inches wide and an inch and a half deep, running in a direction twenty-nine degrees west of south. The smaller grooves run about eleven degrees east of south. One of these planed surfaces at Weeping Water can be seen for about one hundred yards. See figs. 101, 102.

Fig. 104.—Typical rolling loess prairíe, virgin prairie.

On many of our hills and ridges the drift lies on the surface, and one can see occasional piles of boulders hauled from the fields, but ordinarily the drift is covered by loess, which will be briefly described next. There is little of economic importance in the drift save it is very fertile and contains certain valuable gravels and sand beds, and its boulders are used extensively for building purposes.

THE LOESS FORMATION

The loess, bluff deposit, or "yellow clay," constitutes the cultivable soil of the eastern half of the state, and is

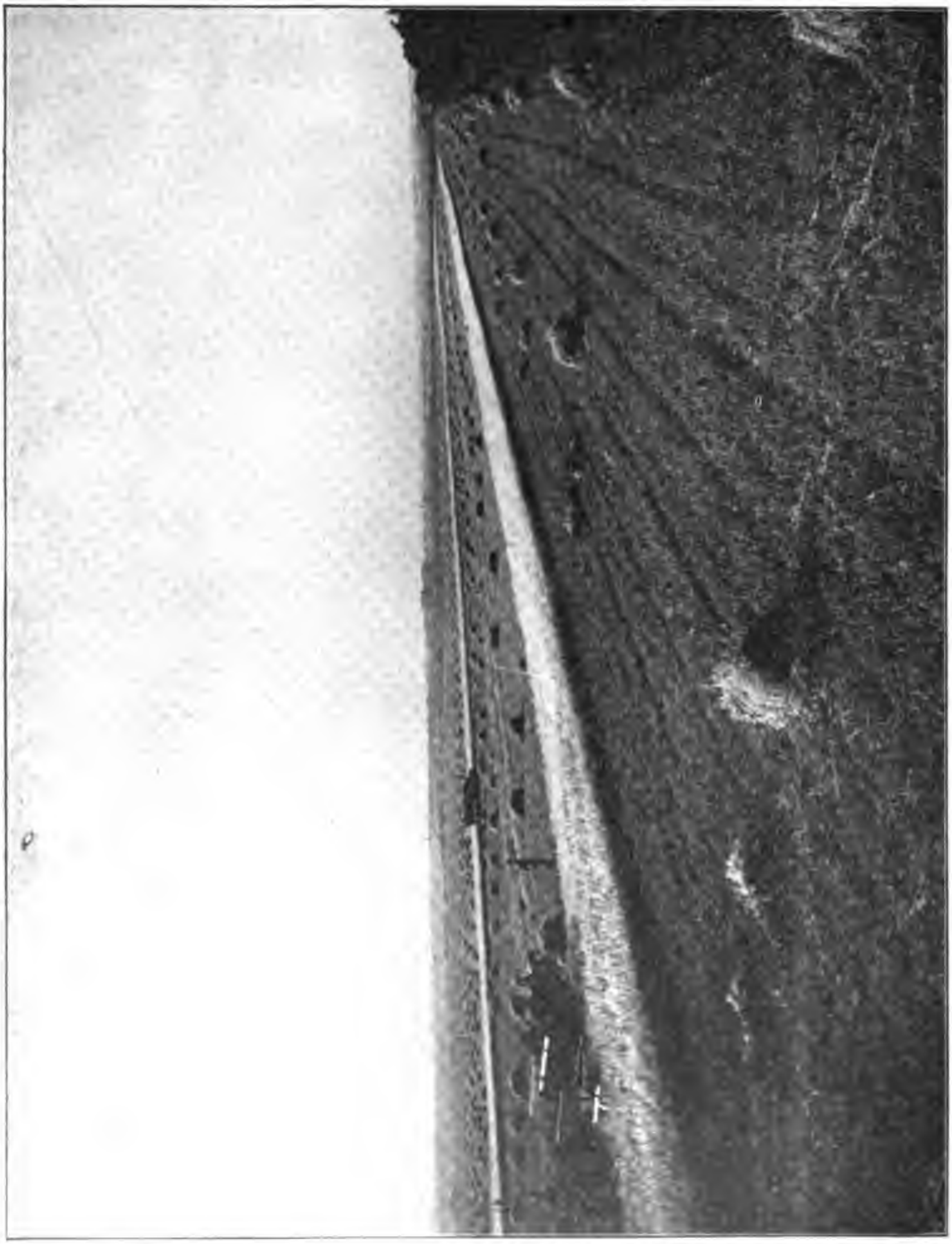


Fig. 105.—Industrial scene on the Cornell farm near Auburn, Richardson county, Neb. Oat field in the foreground, wheat field in the background. This represents typical level loess prairie under cultivation, with scant growth of timber and rolling prairie in the distance. Photograph by U. G. Cornell, University Photographer and Engraver.

therefore very well known and of the utmost economic value because of its boundless fertility and depth.

As the accompanying maps will show, the loess runs diagonally across the state from northeast to southwest, and, while occurring in level or rolling plains, in proximity to streams is often cut into walls and canyons. Such bluffs, whether artificial or natural, tend to have a rough, prismatic

Fig. 106.—Industrial scene along the Union Pacific railroad in Dawson county, Neb., showing a loess prairie under cultivation without irrigation. A timber claim may be seen beyond the stacks of grain. The loess soils of western Nebraska are as productive as those of eastern Nebraska, under similar conditions of moisture.

structure, and to stand in walls so noticeably vertical as to give rise to the name Bluff deposit. The loess of Omaha and Council Bluffs is particularly typical. It is a soft, fine, sandy loam with a large proportion of sand or silt, and considerable calcareous matter, and, as a rule, a small amount of clay. Sometimes the proportion of sand or of clay rises, but ordinarily it is the most strikingly uniform bed the geologist can find. Its average thickness is about one hundred feet,

though thin in some places or entirely worn off in others. Being soft, it washes rapidly.

Unlike many eastern regions, the surface soil of Nebraska, whether on the hilltop or in the valley, is uniformly fertile. This same loess, dug fresh from a well and thrown upon the ground, sustains vegetation at once, and quickly changes

Fig. 107.—Two tusks of the mammoth or primitive elephant, partly uncovered. Found in the loess of Gosper county, Neb., on the face of an extensive cut on the Burlington & Missouri River railroad. Length of tusk along the curve, 11 feet; diameter at base, 7 inches. Photograph, Morrill Geological Expedition, 1893.

from the characteristic bright buff color to a dark shade, due to the amount of humic matter in it, and to the oxidation of certain mineral matter scattered through it. In many places visited there seems to be a difference in color and texture between the upper and lower loess, the lower being darker. Seams of sand also divide the loess.

The loess is penetrated by numerous vertical tubes, lined generally with a white coating of lime. Water falling upon

the surface finds its way downward through these tubes, and, since the loess is chiefly sand, little rainfall is lost. Besides, the fine grained material tends to hold water well, and by capillarity to bring water to the growing rootlets, thus enabling Nebraska soils to withstand drouths which

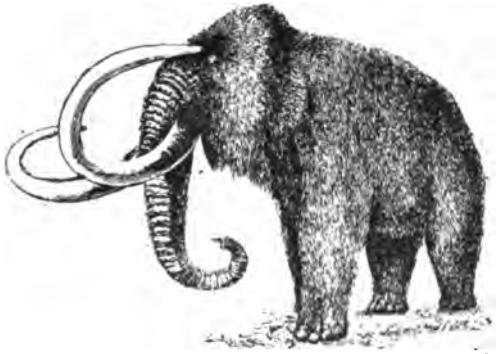


Fig. 108.—Restoration of the mammoth or primitive elephant.

would be simply disastrous in the central states. There are numerous lime balls or concretions in the loess, known in Germany as loess kinderchen and loess puppen, and innumerable land and fresh-water shells, identical with those living. Of the higher order of animals, there are bones and

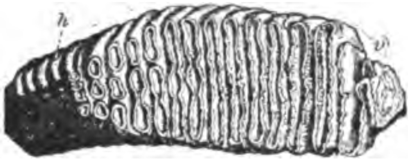


Fig. 109.—Tooth of the mammoth, very common in Nebraska.

Fig. 110.—Tooth of the mastodon, common in Nebraska.

teeth of rodents, and those of the mammoth have been found in many counties. The Pleistocene deposits are full of bones, teeth, and tusks of the mammoth and mastodon.

As to the origin of the loess there are differences of opinion. Structurally, it resembles a wind-deposited material.

However, it may be viewed as the closing act in glacial history. When the general drainage was impeded, and all of the streams congested and forced out of their banks, marshy or shallow lake conditions prevailed and glacial muds were steadily deposited. These we call loess.

Some view the wind as the chief agent. The loess is laid evenly over hills and hollows alike, and some think this can be accounted for only by the wind. The internal arrangement also argues for the wind theory.

It must be admitted that the velocity of our wind is high, and the power to transport dust, silt, and sand correspondingly great, and that the wind must have been one of the factors to be reckoned with in accounting for the loess; still, we are compelled, without entering into arguments, to view it as so much glacial mud and slush, deposited in the retreat of the ice.

The chief economic advantages of the loess are agricultural, and lie in its remarkable depth and inexhaustible fertility, its power to catch and to conserve the rainfall, and to withstand drouth. These are important agricultural advantages; but the deposit is also of great advantage to brick makers, as well as to those buyers who wish to get cheap brick. The process of making brick from loess is simple, and where the material is more argillaceous than usual the brick are excellent. When pressed dry, a very superior product results, beautiful in color and fine in texture, with true edges and faces, of lasting quality, and capable of sustaining heavy pressure tests. The Klose Bros., of Lincoln, have their extensive brick business based on the utilization of the loess, and they turn out a great number of brick of various grades. Since the loess is so widely distributed in Nebraska, it may be viewed as a resource without geographic limit, and limited only in its development by the price of fuel.

If any one fails to recognize the loess, let him compare the shells obtained in his bank with those shown in fig. 111 and he can make his identification sure.

A FEW CHARACTERISTIC LOESS FOSSILS OF NEBRASKA

Helicina occulta Say, Succinea avara Say, Pyramidula striatella, Succinea grosvenorii Lea, Pyramidula shimekii (Pils.) Shimek, Bifidaria pentodon Say, Sphyradium edentulum alticola, Succinea ovalis Say (obliqua), Pupa muscorum L., Enconulus fulvus, Pyramidula alternata, Poly-

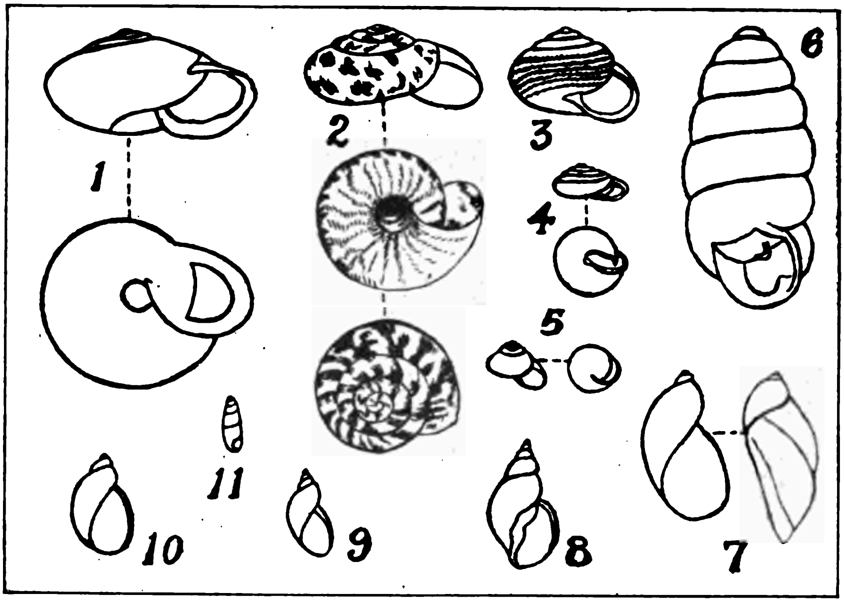


Fig. 111.—A few fossil shells introduced to assist in the identification of the loess formation.

1. Polygyra albolabris (Say) Pils.
2. Pyramidula alternata (Say) Pils.
3. Polygyra multilineata (Say) Pils.
4. Polygyra monodon fraterna (Say) is.
5. Helicina orbiculata Say
6. Pupa muscorum Lin.
7. Succinea ovalis Say
8. Limnaea caperata Say
9. Succinea avara Say
10. Succinea grosvenorii Lea.
11. Cochlicopa lubrica (Müll.)

gyra multilineata, Polygyra profunda, Polygyra leai (Ward) Pils., Vallonia gracilicosta Reinh., Zonitoides arboreus Say, Vitrea hammonis (Ström.), Helicodiscus lineatus (Say), Morse, Cochlicopa lubrica Pils., Bifidaria armifera (Say) Ster., Limnaea caperata Say.

THE SANDHILLS

The sandhill region has already been spoken of as becoming more stable since its settlement by the white man. Since the extermination of the native wild herds which trampled its grasses and loosened and exposed the sand to the transporting power of the wind, and the expulsion of the native people, who made a practice of setting fire to the prairie grasses, the sandhills have become stable instead of shifting as formerly. They are completely grassed over, and some of the best grazing and alfalfa land in the state is in the heart of the sandhill country.

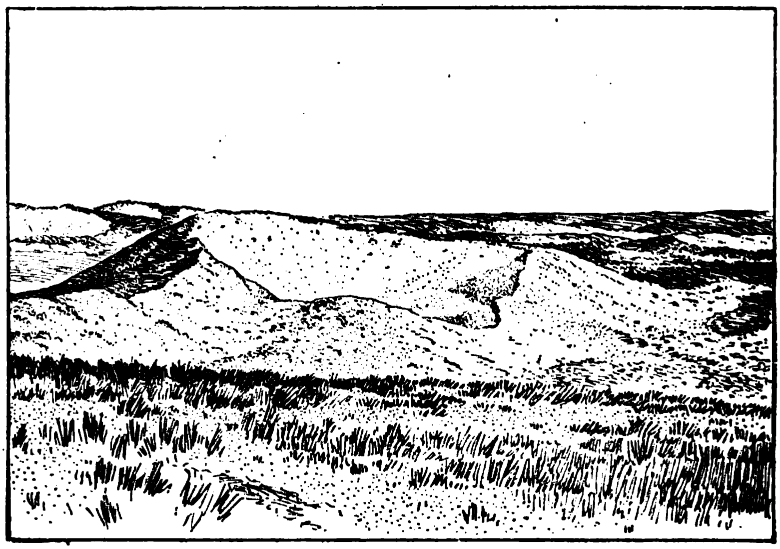


Fig. 112.—Typical sand dune with "blow-out" in its top.

In former times the sand was blown into hills and ridges, rising in places to two hundred and three hundred feet.

As to the origin of the sandhills, which cover hundreds of miles, it may be said that the sand is derived from Tertiary sandstone, chiefly that of the Arikaree. Since Tertiary sandstones are young and poorly consolidated, and crumble readily under the action of the weather, they quickly break down into sand. In many of the sand counties, where the sod is

broken by the plow, the fields are blown away, as described by the farmers and ranchmen, being literally removed, at least as deep as plowed.

It is commonly reported that eastern farmers after moving west insist on maintaining eastern methods of cultivation, contrary to the advice of experienced residents. So later they naturally have reverses to report.

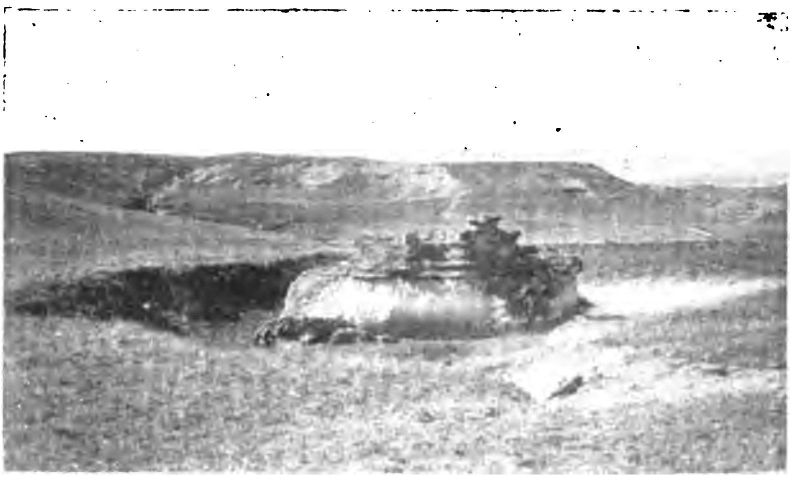


Fig. 113.—Blowout and core, Arikaree formation, Eagle crag, Sioux county, Neb. Photograph, Morrill Geological Expedition, 1891.

Properly understood and properly treated, the sandhills are of economic importance, since they are capable of sustaining great herds, and in addition can be cultivated so as to produce forage and other crops, and have many lakes and springs supplying perennial streams for stock and irrigation.

It is interesting to note that many farmers report alfalfa as growing luxuriantly in the moister places, and even creeping up the side of the sandhills, and since it is generally reported that water is found within a few feet of the surface and readily reached by the deep growing alfalfa roots, there is great expectation of producing large quantities of this valuable crop for home consumption and for shipment.

ALLUVIAL DEPOSITS

Alluvium, or valley wash, occurs to a greater or less extent in all of our river valleys, constituting the level valley floor so sought after by the settlers because of its well-known fertility. The alluvial deposit along the Elkhorn, though narrow, sustains a large population, and is so productive as to resemble a model hay field throughout its length, as viewed from the F., E. & M. V. railroad. The valley of the Platte is so extensive and productive as to sustain a large population, and varies from a few miles in width to fifteen miles in the central part of the state.

The valleys of the Republican, Blue, Niobrara, and even the lesser streams all have alluvium, and are of great agricultural importance. Our Cretaceous and Tertiary rocks, being soft, are the more easily cut into wide valleys, and so afford broad floors for the deposit of alluvium.

Alluvium consists essentially of a heterogeneous mixture of fine soil or loam, silt, sand, gravel, and pebbles, and occasional beds of clay, all more or less mixed with ground-up vegetable matter or humus, and as a soil it contains all the elements of fertility, besides being so situated as to have a subsoil abounding in moisture.

Another economic feature of alluvium is its clay beds. By the assorting power of water certain irregular banks of clay are deposited, generally mixed with sand. This is used in many places for the production of brick. A short paper on the Comparative Value of Bluff and Valley-wash Deposits as a Brick Material, by C. A. Fisher, may be found in the annual report of the State Board of Agriculture for 1900.

Alluvium is the last and youngest of the geological deposits, and, although it was forming when the river first began to flow, its deposition still continues, and brings the alluvial formation up to date.

MINERAL RESOURCES

While Nebraska is counted the most distinctly agricultural state in the Union, it is not without mineral resources,

though they have not been made known. But, since it transpires that our mineral resources are few, it seems safe to assume that there is all the greater burden of responsibility laid on us to make the most of what we have. Mineral resources of the metallic order are practically wanting; those of the non-metallic order are represented by certain important and extensive beds.

GOLD

Native gold occurs in the state in the sands of the Platte and in the glacial drift, and several parties interested have, after a number of years, panned out a few dollars worth of these gold scales or nuggets. They are very small, but real. However, they are so small and so widely scattered that it seems improbable that the day can ever come when the gold will be of the least economic importance. The geologist regrets that it is necessary to report it in this way, for of late strong hopes have been built on gold mining in Nebraska, and considerable sums sacrificed in developing the work.

The older residents say that these gold excitements have recurred periodically for the last thirty-five years, and it is stated on good authority that the gold excitement in Iowa, Kansas, and Nebraska is kindled and kept alive by men who are working ostensibly for the development of mining interests, but really are working in behalf of certain manufacturers of mining and pumping machinery. Nearly every town from Milford and Crete to Gering has had its gold excitement, but, from the point of view of the geologist, gold in paying quantities can not be hoped for in Nebraska. At Crete the mayor and others tested forty wagon loads of the so-called auriferous sand of that place, and secured, altogether, about eight dollars worth of gold. This seems to be entirely authentic. Analyses of the sands at Crete show traces of gold; some yield ninety cents to the ton; others less authentic yield a dollar or two per ton.

At Milford, the burden of this work has fallen on Mr. Dillenbeck, who has devoted the past six or eight years to

the investigation of the glacial sands of his place. He has taken the pains to try various methods of gold extraction, has bought and set up machinery, and has gone to the expense of having many assays made. Many of the prosperous farmers of Pleasantdale and Milford have cooperated with Mr. Dillenbeck in this work.

Gold has been variously reported from layers of iron pyrite in Harlan county, and gold and silver from some of the deep wells in Omaha. Analyses of gold have been made in nearly every county, but many of them lack authenticity or have been lost, and the record is very meager.

As a rule these analyses run low, but a few, apparently entirely authentic, run so high as to cause them to be discredited. A single fragment recently brought to the department of chemistry at the State University was bristling with free gold, and gave an assay of four thousand to five thousand dollars per ton. It must be understood that this was a mere fragment, and in spite of all efforts those interested could find no more.

In this connection it seems advisable to say a word about iron pyrite, which is constantly sent to the office of the geologist for determination. It is very like gold in appearance, so much so that it has long been called "fool's gold." We can think of no simpler test for the average home than to pound the grains; if it is gold, the grain will flatten because of the great malleability of gold; if iron pyrite, it will break into powder. Roast a little of the iron pyrite on a hot stove-lid, and it will give off sulphur fumes, turn black, and become magnetic, which gold will not do.

It is also an almost daily occurrence for the geologist to receive samples which turn out to be mica scales. In the glacial drift there are boulders and pebbles of granitic rock; on rotting down, the mica scales are liberated, and since it happens that mica closely resembles gold at some of its stages of decomposition, many are deceived by its color. Perhaps the simplest test on the farm is to try picking it into scales and to test its malleability by pounding it. It sometimes has a strikingly silvery look, but it is merely an imitative color.

The writer has been shown samples of genuine gold, well authenticated as coming from the river sands and from the glacial drift, but its occurrence is simply a matter of interest to mineralogists, and it is to be feared that gold in Nebraska can never have the least economic importance.

COPPER

The writer has been shown small flattened grains of native copper found in Cherry and Nemaha counties. There is also preserved in the State Museum a piece of native copper, weighing about one-half ounce, found in Chase county, near Imperial, in a well at a depth of ninety-two feet. Pl. VIII, fig. 16. This seems to be authentic. Other bits have been reported from other counties, but most of them are plainly bits of ore from the Rocky mountain regions accidentally dropped or lost in Nebraska. Aside from the fragments already described, there is no copper in Nebraska. The little found and reported interests the mineralogist, but has not the slightest economic significance.

TERRESTRIAL IRON

Pure iron has been reported from Auburn, and in the museum of the department of chemistry in the University of Nebraska may be seen carefully preserved specimens. It is found in a tenacious clay at a depth of some sixty feet, and, according to the report of well diggers, is sufficient in amount to interfere with well digging. The individual bits of terrestrial iron resemble the common bean in shape and size, although some are as large as a pigeon's eggs. Such occurrences are very rare, for iron almost never occurs pure in nature, but is always combined with some other element, such as oxygen, sulphur, etc. Associated with this very unique native iron are grains of native copper.

METEORIC IRON

Pure iron meteorites have been found in Nebraska, but the commonest form of "meteorite" which has been

brought to the department of geology for determination is that found in burnt hay and straw stacks. It is very common for a sort of glass to be produced by such combustion, and to the inexperienced it is not unlike meteoric stone in appearance. Finding such in the ash of a burnt stack, and believing that meteorites are superheated, the popular inference is that the stack was fired by a shooting star, and that the solid glassy substance is a real meteorite.

Another fruitful source of meteorites is the concretionary layer in the Dakota Cretaceous. Our Cretaceous is so charged with iron that in many places it has the appearance of a sand semi-fused, or that of coarse cast iron. Such, at least, is the popular impression of it. It is very common to find throughout this stratum nodules filled with colored sand; sometimes, however, they are solid and ring under the hammer and break like cast iron. These are a source of constant concern to many, who think they have found a bed of meteorites. They are repeatedly brought to the department for determination.

The first genuine meteorite found in Nebraska, weighing 835.2 grams, was turned up by the plow in York county in 1878, and is shown in figs. 114 and 115. When a corner of this meteorite was planed and burnished, unmistakable indications of Widmanstätten figures were brought out, as shown in fig. 118, and when the same surface was etched, the Widmanstätten figures shown in fig. 119 were produced.

By the courtesy of Mr. George F. Kunz, the writer is able to publish the following analysis of the above meteorite:

Iron	87.96 per cent
Nickel	7.38 per cent
Cobalt	0.74 per cent

In Huntington's catalogue of the recorded meteorites, brought down to 1887, there is reported from Fort Pierre, in Nebraska, a meteorite which fell in 1856, consisting of two fragments, weighing respectively thirty-five and twenty-eight grams, which he numbered in his catalogue 225. This is probably a mistake, for Fort Pierre is in South Dakota,

Figs. 114, 115.—Two views of the York county meteorite, somewhat reduced.

Figs. 116, 117.—Two views of the Red Willow county meteorite.

which will leave the York county meteorite as the first recorded in the state.

Later a much larger iron meteorite was found in Red Willow county, weighing 6.13 pounds (2,776 grams), as shown in figs. 116 and 117. This excellent specimen has been badly pounded by a hammer on one face. When a small face was planed, polished, and etched, faint and indistinct Widmanstätten figures were developed. This is attributed to the crystalline derangement incident to the pounding to which it had been subjected.

A third meteorite was found in Rock county, the finder vouching for the fact that he observed it fall between twelve and one o'clock on the night of October 16, 1898, that it was luminous, and that it made a loud noise in its descent. This was the first fall of a meteorite observed in the state. It weighed twelve ounces (340 grams). The Lancaster county meteorite, just brought to light, weighs twenty-nine pounds, and is of the iron type.

Two other meteorites have been reported, one of which seems to be authentic, but not having been seen it can not be announced here.

All iron of this type is extra-terrestrial, coming to the earth from unknown distances in the skies.

A list of the meteorites, so far as the writer can learn, is as follows:

1. The York county meteorite, iron type, weight 835.2 grams, 1.84 pounds.
2. Red Willow county meteorite, iron type, weight 2,776 grams, 6.13 pounds.
3. Rock county meteorite, iron type, weight 340 grams, 12 ounces.
4. Lancaster county meteorite, iron type, weight 13,150 grams, 29 pounds, received while this was in press.
5. Iron meteorite reported, undoubtedly authentic, weight about thirty pounds.
6. One large meteorite of the stony type, lacking confirmation.

IRON PYRITE

Iron in the form of pyrite (iron sulphide) is very common in the clays, shales, and rocks, sometimes occurring as scattered crystals, or as strings or balls of crystals, or as nod-

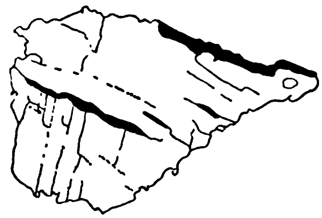


Fig. 118.—Natural Widmanstätten figure brought out by burnishing.

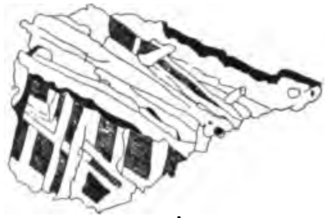


Fig. 119.—The same when etched, York county meteorite.

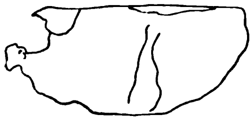


Fig. 120.—A burnished surface of a meteorite found in Red Willow county, Neb.

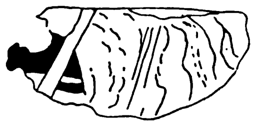


Fig. 121.—The same when etched.

Fig. 122.—Rock county meteorite.

ules. Iron pyrite as found in Nebraska is not only valueless, but is a positive detriment, for the presence of even small amounts of it in the rocks damages or ruins them. See pl. VIII, figs. 1, 2, and 3.

MARCASITE

Ordinary pyrite crystallizes in cubes, but there is another form of pyrite identical in composition, but differing crystallographically, called marcasite. Most of the nodules found in the state are marcasite, although for the use of citizens there is no need to distinguish between pyrite and marcasite.

LIMONITE

Iron in the form of limonite is found in the Dakota Cretaceous, and, though commonly called iron ore, which it is in fact, yet as such it has no value. Limonite ore in the form of ochre is known in a number of places in the northeastern counties on the Platte river and along the Republican river. The best deposit is supposed to be that at Indianola, Red Willow county. Here it is reported to be twenty to forty feet thick and very uniform, and free from sand and silt. At one time a mill was built, which is still standing, and excellent paint was produced, and the citizens of the state hoped that a useful resource would be developed. For a time there was a considerable output, but for several years the mill has been closed. In the region about Indianola well diggers report that this bed of ochre is encountered everywhere, so, according to accounts, the amount is large. By roasting the ochre various colors are produced, ranging from light yellow tints to medium and deep shades of red and brown. Iron paints are cheap and particularly serviceable.

In certain swamps hard pan or bog iron has been reported, but it is safe to say that iron ores are not likely to be found in Nebraska.

MAGNETIC IRON SAND

Magnetite in the form of magnetic sand is very common, and is easily tested. It is a black and strikingly heavy sand, easily panned out, highly magnetic, and so much of it is sent to the office of the Geologist for determination that he is led to explain here that any common horseshoe magnet

to be had at hardware or drug stores will pick up this sand and show thereby that it is magnetite. It has not the slightest value in Nebraska, although the same sand in large workable beds is a valuable source of iron.

PHOSPHATE OF IRON

Phosphate of iron, or natural Prussian blue, has been found in Franklin county, and is described by Dr. Fulmer, of the chemical department of the State University. This occurs as blue and yellow nodules, and children grind these into colored inks, a use which led to the discovery of the mineral.

Fig. 123.—Dendrite or tree stone (oxide of manganese) on Carboniferous limestone.

LEAD AND ZINC

Lead in the form of galenite (lead sulphide) and zinc in the form of sphalerite (zinc sulphide) are reported as occurring in the state, but the writer has not been able to confirm the report, and discredits it.

PYROLUSITE

Pyrolusite, or manganese dioxide, is common in many of our rocks, clays, and sands, but in Cheyenne county it occurs in numerous radiating nodules about the size of walnuts, as

shown in plate VIII, figs. 9 and 10. It is common also as a black tracing, imitative of plants or miniature trees, and is called dendrite or tree-stone. In one place it occurs as a hard-pan, offering considerable resistance to the plow. Though of great use in the arts and once worth many dollars a ton, this mineral at present is useless unless occurring in large quantities.

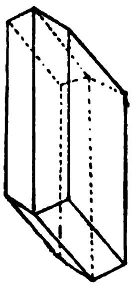


Fig. 124.—Crystal of selenite common in our Cretaceous shales.

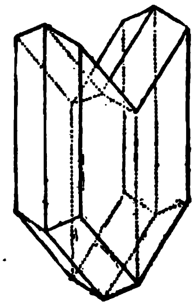


Fig. 125 —Twin crystals of selenite.

GYPSUM

Gypsum, so common in South Dakota, Kansas, and Oklahoma, is wholly wanting in Nebraska, save as we find the crystallized form of gypsum, called selenite (lime sulphate). These crystals, which are shown above, occur in considerable numbers in the Benton and Pierre shales. They are transparent, cleave easily, and are very soft, facts that may be used in determining the species. If you can scratch the mineral easily with the finger nail and it splits or cleaves, it is doubtless selenite. Found in the form of scattered crystals this resource is without economic importance save to a very limited number, who collect and sell the crystals to eastern dealers.

BARITE

Barite or heavy spar (barium sulphate) occurs in great numbers as small, rhomboidal, or diamond-shaped, flat, yellowish crystals, scattered throughout the clays near Odell,

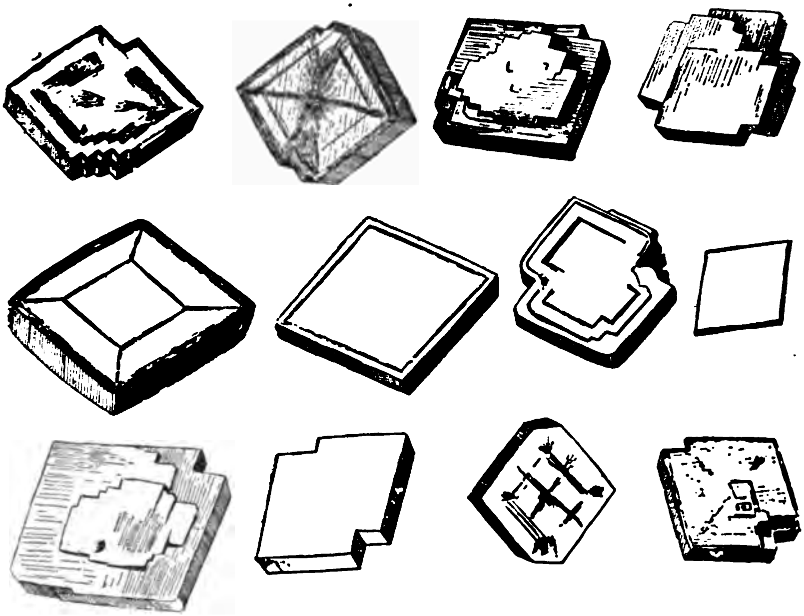


Fig. 126.—A group of barite crystals from the "Diamond Fields" of Gage county, Neb., as they appear when dug from the clay, magnified about three diameters.

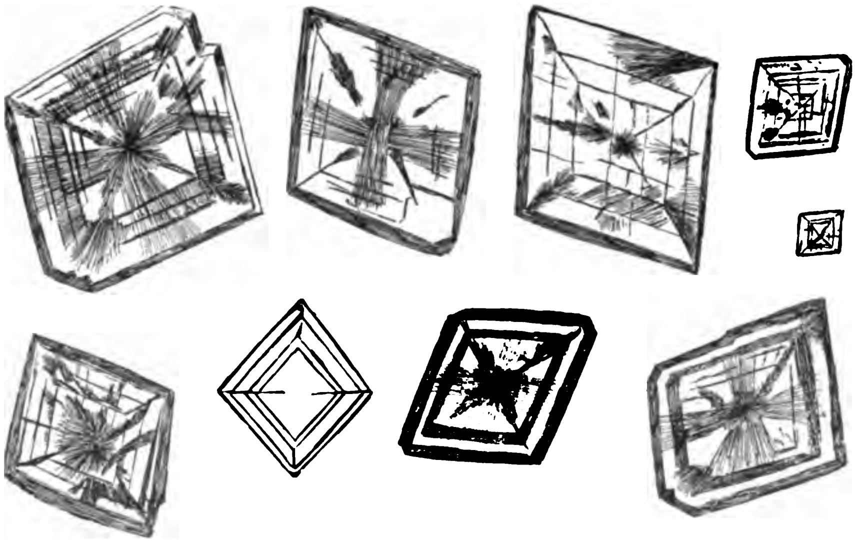


Fig. 127.—A group of barite crystals from the Gage county "Diamond Fields," viewed by transmitted light, showing phantom figures, magnified three diameters.

Gage county. The places yielding these crystals are known locally as the diamond fields, in allusion to the shape of the crystals. The simplest test is to hold them to the light and look for the phantom figures shown in figs. 126 and 127. Barite is common in the Bad Lands, in narrow seams and scattered crystals, and is valuable in the arts, and there is a demand for it in the manufacture of beet sugar; but it occurs sparingly in Nebraska.

CELESTITE

Celestite (strontium sulphate), closely related to barite, occurs sparingly as clear blue narrow crystals in geodes in the vicinity of Wymore and Holmesville, and in imperfect scattered crystals in the Bad Lands. Pink or reddish celestite occurs in nodules near Roca.

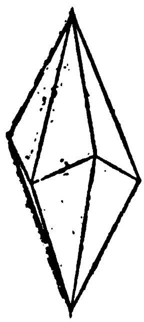


Fig. 128.—A scalenohedron of calcite known everywhere as dog-tooth spar.

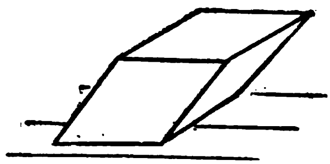


Fig. 129.—Calcite crystallizes and cleaves into rhombohedrons resembling flattened cubes.

CALCITE

Calcite, or lime carbonate, is the commonest mineral found in the state. Limestone may be viewed as calcite, being carbonate of lime, but the kind here referred to is the pure, transparent calcite, which cleaves so readily into little blocks, which resemble cubes tipped out of plumb. This property is to be used as a test in determining calcite on the farm or in the quarry. A surer test is to powder a little and drop it in vinegar or other acid, when it will effervesce if it

is calcite. Rhomboidal crystals, shown in fig. 129, are common, as also the form called nail-head calcite, but the commonest form is that known everywhere as dog-tooth spar.

An interesting form of calcite—called calcite-sand crystals—has within the year been discovered on the Nebraska-Wyoming line, being in form a combination of acute and obtuse rhombohedrons. The sand in these crystals is simply

Fig. 130.—Calcite-sand crystal from western Nebraska, being, crystallographically, a combination of acute and obtuse rhombohedrons.

Fig. 131.—Theoretic form of same for comparison.

cemented into this form by the calcite. It is calcite crystallizing between the grains of sand which makes our "Cretaceous quartzite." Rock faces in quarries, cavities in the rocks, geodes, etc., are often lined with calcite crystals. In the Bad Lands it occurs as crystal balls, as shown in plate VIII, fig. 18.

Miscellaneous Minerals

Agate, amethyst, carnelian, labradorite, and garnet are commonly found in the glacial drift of the eastern part of the state, and in the Rocky mountain drift of the western

part, but it should be remembered that none of these are native.

AGATE

Moss agate is found in position on the ranch of James H. Cook at Agate post-office, Sioux county, Neb.

These beds of moss agate were plainly well known to the native tribes, inasmuch as many chips, arrow points, and

Fig 132.—Moss agate worked into the form of an implement by the Indians.

Fig. 133.—Specimens of moss agate from the ranch of James Cook, Agate, Neb., cut into a charm, enlarged.

other implements are found made of this material. In color it varies from transparent to reddish and brownish tints. The transparent varieties when polished show the jet black dendrites within and make charms which wear well and are prized by many. See figs. 132 and 133

CHALCEDONY

Chalcedony, which is a kind of agate variously colored and shaped, is common, especially the browner sorts, which occur

as vertical sheets or dikes cutting the Bad Lands. Pl. VIII, fig. 17.

TURQUOISE

Three small but excellent turquoises have been found in Brown county, one of which made a handsome stone when cut and mounted by a lapidary in Boston. This turquoise, as nearly as the writer could judge, is of the variety known as Odontolite or Tooth turquoise, the tusks of mammoths being sometimes converted into this variety of turquoise.

DIATOMACEOUS EARTH

Beds of diatomaceous earth of some extent, and of a thickness varying from a few inches to five or six feet, are known in the central counties of Nebraska, particularly in the region of the Loup system. Samples have been received which were collected in Hooker, Thomas, Blaine, Garfield, Wheeler, Valley, Greeley, Sherman, and Nance counties. The best beds seem to be those of Greeley county, where they are numerous and of one to two or more feet in thickness. The diatomaceous layers alternate with sand and peat.

Several exposures are reported from Hooker county, one varying from one to five or six feet in thickness, with about fifty feet of overlying soil. Another bed is reported to vary from one to three feet. These beds outcrop along the banks of streams, some twenty to thirty feet above water. From this region comes a fairly hard limestone, which, when dissolved, is resolved into diatom frustules and sponge spicules.

While plowing and scraping in Thomas county for an irrigation ditch, within half a mile of Thedford, the construction gang went through a bed about eighteen inches thick. Ten to fifteen rods beyond the ditch, it expanded to nearly five feet. The overlying soil varied from one to ten feet. In extent the bed covers several acres, and within a radius of three miles similar deposits abound. The State Museum has a four-foot section of diatomaceous earth cut from a six-foot bed in Wheeler county. The beds here, of which there

are a number, occur up and down Cedar creek, and the thickness is usually from one to three feet. The same beds are found in Greeley, Nance, Valley, and Sherman counties.

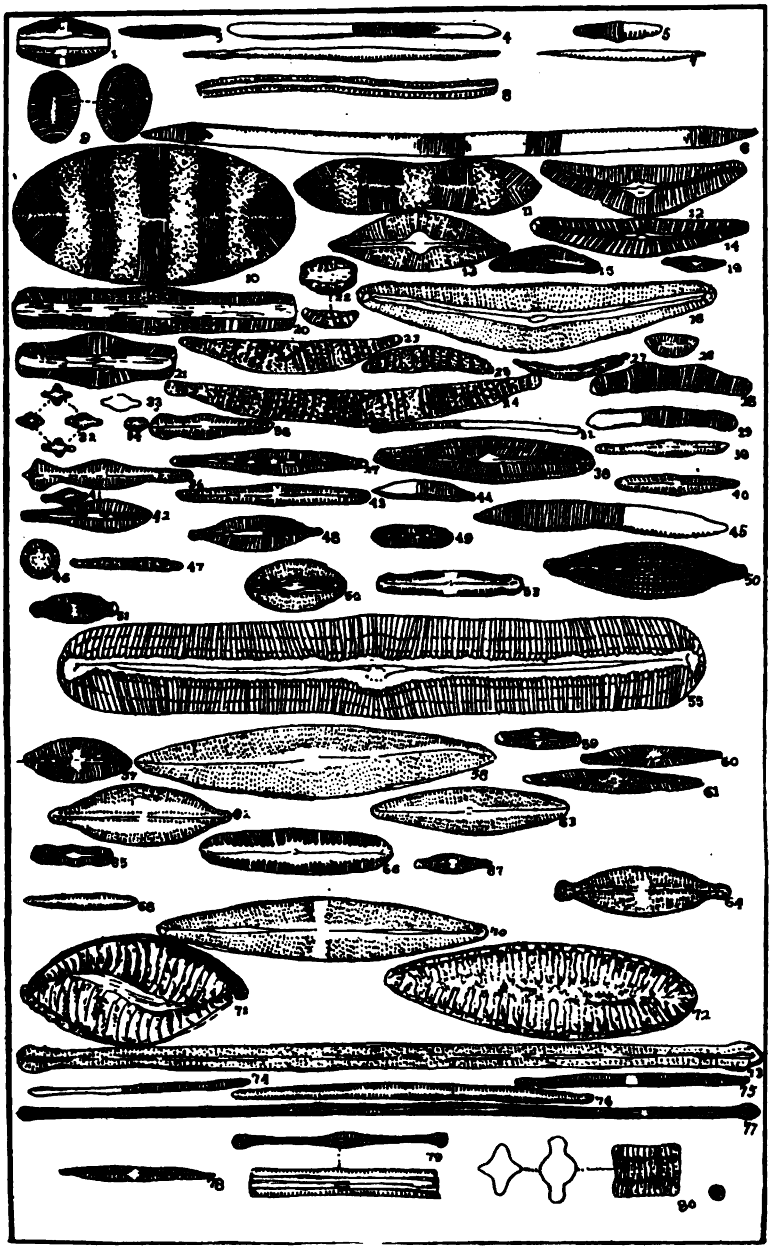
The beds of Wheeler and Greeley counties, which outcrop frequently along Cedar creek, lie under a bed of peat some two to three feet thick.

Samples from Hayes county, when examined, consisted of diatoms and pumiceous dust, or volcanic ash, which is common throughout the state. Possibly these were wind-borne diatoms, as was the dust.

As to the origin of these beds, it may be explained that they are composed of the silicious shells of microscopic sea-weed, known as diatoms. Students who have examined the deposits in Nebraska find the diatoms like those of similar deposits made in glacial time, and so refer our beds to that age.

LIST OF DIATOMS SHOWN IN PLATE VII AS IDENTIFIED BY CLARENCE J. ELMORE

1, Amphora ovalis (Breb.) Kuetz. var. gracilis (Ehr.) V. H. 2, Bacillaria amphibia (Grun). 3, Bacillaria amphibia var. frauenfeldii (Grun). 4, Bacillaria obtusa (Ag.) 5, Bacillaria sinuata (W. Sm.) Grun. 6, Bacillaria spectabilis (Ehr.) Ralfs. 7, Bacillaria subtilis (Kuetz.) Hantz. 8, Bacillaria vermicularis (Kuetz.) Hantz. 9, Cocconeis placentula Ehr. 10, Cymatopleura elliptica (Breb.) W. Sm. 11, Cymatopleura solea (Breb.) W. Sm. 12, Cymbella cistula (Hempr.) Kirchn. 13, Cymbella cuspidata Kuetz. 14, Cymbella cymbiformis (Kuetz.) Breb. 15, Cymbella cymbiformis var. parva (W. Sm.) V. H. 16, Cymbella gastroides Kuetz. 17, Cymbella inequalis (Ehr.) 18, Cymbella lanceolata (Ehr.) Kirchn. 19, Cymbella laevis Naeg. 20, Cystopleura gibba (Ehr.) Kuntze. 21, Cystopleura gibba var. ventricosa (Ehr.) Grun. 22, Cystopleura ocellata (Ehr.) Kuntze. 23, Cystopleura turgida (Ehr.) Kuntze. 24, Cystopleura turgida var. vertagus (Kuetz.) Grun. 25, Cystopleura zebra (Ehr.) Kuntze. 26, Encyonema caespitosum



FOSSIL DIATOMS OF NEBRASKA, NUMBERED ACCORDING TO LIST OF DIATOMS ON PP. 194, 195, MAGNIFIED ABOUT 300 DIAMETERS

Kuetz. 27, Eunotia arcus Ehr. 28, Eunotia diodon Ehr. 29, Eunotia formica Ehr. 30, Eunotia formica var. elongata Grun. 31, Eunotia lunaris (Ehr.) Grun. 32, Fragilaria construens (Ehr.) Grun. 33, Fragilaria construens var. venter Grun. 34, Fragilaria elliptica Schum. 35, Gomphonema acuminatum Ehr. 36, Gomphonema constrictum Ehr. 37, Gomphonema gracile Ehr. 38, Gomphonema herculeanum Ehr. 39, Gomphonema intricatum Kuetz. 40, Gomphonema montanum Schum. var. subclavatum Grun. 41, Gomphonema parvulum Kuetz. 42, Gomphonema turris Ehr. 43, Gomphonema vibrio Ehr. 44, Hantzschia amphioxys (Ehr.) Grun. 45, Hantzschia amphioxys var. major Grun. 46, Melosira distans (Ehr.) Kuetz. 47, Meridion constrictum Ralfs. 48, Navicula ambigua Ehr. 49, Navicula bacilliformis Grun. 50, Navicula cuspidata Kuetz. 51, Navicula dicephala Ehr. 52, Navicula elliptica Kuetz. 53, Navicula limosa Kuetz. 54, Navicula macilenta Ehr. 55, Navicula nobilis (Ehr.) Kuetz. 56, Navicula parva Ehr. 57, Navicula placentula (Ehr.) Kuetz. 58, Navicula placentula var. tumida W. Sm. 59, Navicula pupula Kuetz. 60, Navicula radiosa Kuetz. 61, Navicula radiosa var. acuta (W. Sm.) Grun. 62, Navicula rostrata Ehr. 63, Navicula serians (Breb.) Kuetz. 64, Navicula sphaerophora Kuetz. 65, Navicula trinodis (W. Sm.) Grun. var. inflata, Schultze. 66, Navicula viridis (Nitz.) Kuetz. 67, Navicula viridula Kuetz. var. slesvicensis Grun. 68, Opephora pacifica (Grun) Petit. 69, Stauroneis minutissima Largerst. 70, Stauroneis phoenicenteron (Nitz.) Ehr. 71, Suriraya spiralis Kuetz. 72, Suriraya splendida (Ehr.) Kuetz. 73, Synedra capitata Ehr. 74, Synedra radians Kuetz. 75, Synedra tenuissima Kuetz. 76, Synedra ulna (Nitz.) Ehr. var. amphirhynchus (Ehr.) Grun. 77, Synedra ulna var. longissima (W. Sm.) Brun. 78, Synedra ulna var. oxyrhynchus (Kuetz) V. H. 79, Tabellaria fenestrata (Syngb.) Kuetz. 80, Tetracyclus lacustris Ralfs.

An average section of the Greeley county deposits is as follows:

Sections in Greeley county..	Soil of varying thickness. Sand of varying thickness. Peat of varying thickness, one to two feet. Diatoms six inches to two feet.
Some sections are thus......	Sand. Diatoms. Sand. Diatoms. Sand.

HOOKER COUNTY DIATOMACEOUS LIMESTONE

The diatomaceous limestone of Hooker county, when treated with hydrochloric acid, yielded forty species as identified by Mr. Elmore. The following is a list of the more prominent of these, numbered in conformity with the preceding list: 1, 2, 4, 5, 6, 7, 12, 14, 15, 16, 17, 18, 20, 21, 23, 24, 25, 31, 35, 37, 40, 44, 46, 48, 49, 50, 56, 57, 60, 63, 66, 70, 73, 76.

Fresh water only	27
Fresh or submarine	10
Submarine or marine	1
Doubtful habitat	1
Fossil only	1
	40

Thirteen have been reported as fossil; twenty-seven have not as yet been so reported.

Of the forty species, twenty-five are now found living in Nebraska; fifteen not yet found living in Nebraska.

HOOKER COUNTY DEPOSITS

In the Hooker county diatomaceous earth, sixty-eight species were recognized.

Fresh water only	52
Fresh or submarine	10
Fresh or marine	1
Marine	1
Doubtful habitat	1
Fossil only	3
	68

Of this number, twenty-four have been reported as fossil;

forty-four have not been so reported heretofore. Thirty-nine of the sixty-eight species are now found living in Nebraska. The remaining twenty-nine have not yet been found living in Nebraska.

WHEELER COUNTY DIATOMS

In the Wheeler county deposits, twenty-five species were recognized.

Fresh water only	17
Fresh or submarine	6
Marine, submarine, or fresh	1
Fossil only	1
	25

Of the twenty-five species, twelve have been reported, and thirteen have not been reported as fossil. Eighteen are now living in Nebraska; seven not as yet found living in Nebraska.

THE HAYES COUNTY VOLCANIC ASH AND DIATOMS

In samples of volcanic ash from Hayes county three species were found: Melosira distans, Cystopleura sorex, and Cystopleura turgida.

USES TO WHICH OUR DIATOMACEOUS DEPOSITS HAVE BEEN PUT

But little economic use as yet has been made of the Nebraska deposits. However, a certain amount is annually put up in neat packages, and rendered attractive by ornamented labels, and sold by small dealers in various towns as an excellent polishing powder, and such in fact it is. It may also be used as a non-conducting packing for steam pipes, water pipes, etc.

Because of a certain similarity in color and texture, citizens of the state often confound diatomaceous earth with the much more common deposit, volcanic ash.

A simple test is at hand. Our diatomaceous earth, in broken blocks, floats like cork till water-logged. Volcanic ash sinks at once.

The surest test is to view it under the microscope. There are few high schools without one or more compound microscopes, and the principal or any of his teachers can instantly identify the deposit by comparing it with plate VII.

PEAT

Peat has already been alluded to as occurring interbedded with diatomaceous earth, sand, clay, etc., along the banks of the Loup system.

Hayden and early geologists called attention to the beds of peat in this state as a possible means of fuel supply, but there has been no development, as far as the writer can learn. In fact, the state is so large that he has not had time to visit the peat beds reported. Several excellent specimens of peat have been sent to the State Museum, and reports of numerous peat bogs come in from those living along the river courses. However, Nebraska would not be looked upon as a peat-producing state.

One peat bog is reported from Logan county as six miles long, of variable width, and fifteen feet in thickness. Good peat beds have been reported also from Greeley and Seward counties. While all of these beds have been reported in good faith and are doubtless reliable, they have not been visited and confirmed by the geologist. This must be done, and a special report must be prepared touching this matter, inasmuch as a number of eastern firms having in view the development of our best peat beds are making inquiry about these deposits, with a view to locating in Nebraska.

Heavy machinery has been devised and is in operation in Canada and eastern states compressing peat, which is often mixed with a little cheap slack and made into bricks which are said to burn well and give good results. Peat may be viewed as incipient coal.

COAL

It would be of the greatest economic importance if coal could be found in our state, and to stimulate investigation the state, for a number of years, has had a standing offer of a lib-

eral bounty for the discovery of a workable bed of coal. Thousands of dollars and months of time have been devoted to the work of coal-prospecting in Nebraska during the past two years, and this same money would have made a geological survey of the state! It is never an agreeable task to inform people that there is little prospect of ever finding coal in their state, but such is the fact in Nebraska. Many of these prospectors have insisted that there is coal east of us in Iowa and west of us in Wyoming, therefore it must of necessity occur here. This seems reasonable, but it is nevertheless fallacious. The Carboniferous in Nebraska is a deep-sea deposit, and the coal beds which are productive in Iowa have thinned out in Nebraska to a few inches. West of Lincoln all coal soon disappears, and there is no coal in the Carboniferous of the Rocky mountains. There the coal is found in the Upper Cretaceous, which does not occur in Nebraska.

At one time, for four or five consecutive years, the total output of coal, mined chiefly by farmers, was estimated at fifteen hundred tons, and valued at six thousand dollars. Recently the Rulo Coal Co., under the direction of Mr. Bullock, of Lincoln, mined coal at Rulo, but the undertaking proved unprofitable and has been abandoned.

In the northeastern counties some coal is being produced; it is a lignite coal from the Cretaceous, and the bed is scarcely eighteen inches in thickness. Other phases of this matter are discussed under the Carboniferous formation.

ANALYSES OF NEBRASKA COAL, BY PROF. H. H. NICHOLSON

No. 5025, from Valparaiso—	
Specific gravity	1.2891
Moisture	7.79
Volatile and combustible matter	36.08
Fixed carbon	35.70
Ash	20.13
	100.00

No. 4831, from Bancroft—

Moisture	13.63
Volatile matter	38.08
Fixed carbon	43.24
Ash	5.15
Qualitative tests showed only very slight traces of sulphur.	100.10

No. 3563, from Nemaha county—

Specific gravity	1.4255
Moisture	4.466
Volatile and combustible matter	36.677
Fixed carbon	45.26
Sulphur	4.090
Ash	9.502
	99.995

No. 1934, from Cass county—

Moisture	13.23
Volatile matter	44.56
Fixed carbon	32.04
Ash	10.21
	100.04

No. 130, from Otoe county—

Specific gravity	1.84
Moisture	7.10
Volatile matter	20.52
Fixed carbon	29.10
Sulphur	6.81
Ash	36.46
	99.99

No. 3945, from Richardson county—

Moisture	7.87
Volatile matter	31.52
Fixed carbon	50.36
Ash	10.26
	100.01

No. 4998, Cretaceous coal, from Dakota county—

Moisture	4.57
Volatile and combustible matter	31.97
Fixed carbon	40.24
Ash	23.22
	100.00

ANALYSES OF DAKOTA COUNTY LIGNITES, BY ERNEST F. BURCHARD, CHEMICAL LABORATORY, SIOUX CITY, IOWA

NO. 1, SAMPLE OF DRILLINGS 3 MILES NORTH OF JACKSON, AT A DEPTH OF 75 FEET, AIR DRIED

Water	4.99
Volatile matter	41.63
Fixed carbon	27.14
Ash	25.72
Sulphur	1.22
	100.70

NO. 2, SAMPLE OF DRILLINGS 3 MILES NORTH OF JACKSON, AT A DEPTH OF 65 FEET (SAME BED), AIR DRIED

Water	4.03
Volatile matter	51.40
Fixed carbon	33.66
Ash	10.91
Sulphur undetermined	
	100.00

NO. 3, SAMPLE OF LUMPS FROM THE SHAFT 3 MILES NORTH OF JACKSON, AT A DEPTH OF 82 FEET, AIR DRIED

Water	6.50
Volatile matter	28.00
Fixed carbon	49.30
Ash	16.20
Sulphur undetermined	
	100.00

ULTIMATE ANALYSIS OF NO. 3, ABOVE

Water	6.05
Carbon	55.20
Hydrogen	3.40
Oxygen and nitrogen	16.90
Sulphur	0.80
Ash	17.20
	99.55

To aid citizens in understanding the composition of our lignite and coal, the following analyses are introduced for comparison:

ANALYSES OF PEAT, LIGNITE, AND COALS

	PEAT	LIGNITE			BITUMINOUS COAL			ANTHRACITE	
	Dismal Swamp	Athens, Texas	Atascosa County Texas	Leon County Texas	Waldrip, Texas	Pennsylvania	Pennsylvania	Pennsylvania	Pennsylvania
Moisture	78.89	9.10	13.285	14.670	4.55	0.9	1.3	2.74	2.93
Volatile matter	13.84	42.20	59.865	37.320	38.50	25.63	20.87	4.25	4.29
Fixed carbon..	6.49	7.37	18.525	41.070	44.80	51.30	67.20	81.51	88.18
Ash	0.78	41.32	8.325	6.690	12.14	17.77	8.80	10.87	4.04
Sulphur	......	0.62	2.360	0.250	7.96	4.4	1.83	0.62	0.55

Good coals run high in fixed carbon and low in water and ash.

CLAYS

The state is particularly rich in good clays, the chiet amounts being found, as already described, in the Carboniferous and Dakota Cretaceous formations.

This being probably the most important single resource, it will be reported in detail in a special paper. It is enough to say that we are importing into the state all kinds of building, paving, and ornamental brick, when we have here the greatest abundance of clays of the best quality. Large brick industries are already established around Beatrice, Table Rock, Omaha, Lincoln, and other cities, and many towns boast of their brick factories. The writer is very sanguine about the possibilities of this resource; it is capable of magnificent development.

It seems possible that some of our clays, especially those containing a proper percentage of iron and lime, may yield material for the production of hydraulic cement. Practical experiments are already being made along that line, although the great source for hydraulic cement is in the chalk rock and shale of the Benton formation.

BUILDING STONES

Limestone constitutes the most important building rock in the state, and many quarrymen are engaged in its produc-

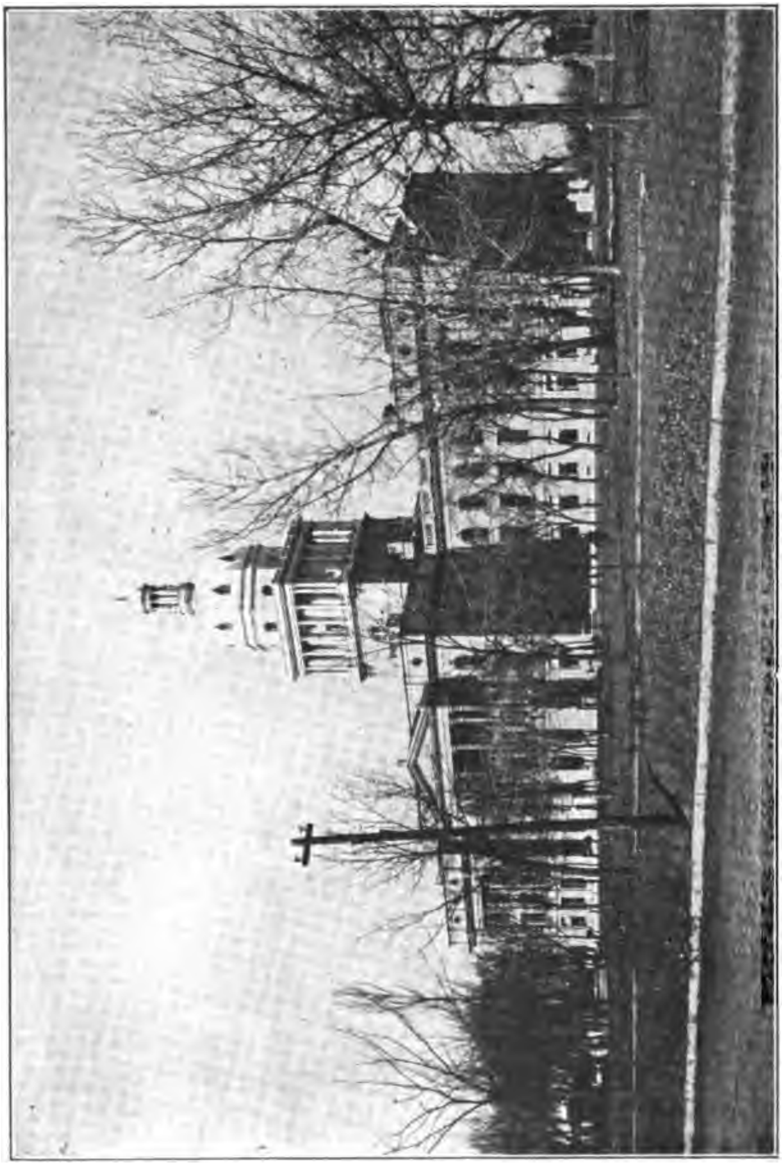


Fig. 134.—State capitol, Lincoln, Neb., built of native Carboniferous limestone.

tion, and while the subject is entirely beyond the scope of this paper, data are already in hand for a special report on our native building stones, many of which have been tested for strength by crushing, freezing, and thawing.

Limestones have already been described under the heading Carboniferous formation, and chalk rock under the Benton formation, and the sandstones under the Dakota Cretaceous formation.

Fig. 135.—Rice stone. Carboniferous limestone, composed of foraminiferal shells, Fusulina secalica.

A warning should be sounded in connection with our limestones of inferior grade. They deteriorate with unusual rapidity, especially those containing clay. The well-chosen varieties look well and last well, but the common grades go to pieces in a season under the action of frost. Miles of curbing in Lincoln have disintegrated in this way in a few years, even our best limestone being too perishable for such use. A brick building trimmed with Nebraska stone, unless the material is well chosen, is constantly streaked white by

lime. Steps, sills, hitching posts, etc., soon weather down and must be replaced, unless carefully selected. Steps to public buildings last but ten to fifteen years at most, not

Fig. 136.—Section of oolitic limestone from the Permian beds at Wymore, Neb.

Fig. 137.—A block of low-grade Carboniferous limestone supporting a post. University School of Music. Almost weathered to pieces at the end of one year.

Fig. 138.—The ordinary limestone of our Carboniferous quarries used extensively in foundations, showing numerous flint nodules and myriads of small shells, Fusulina secalica. In ten years this rock weathered away enough to leave the nodules projecting one inch.

that they wear out under the tramp of feet, but that they weather badly. Those who buy need protection as well as those who sell, and people are warned against the use of poor grades of Carboniferous limestone.

They are also warned against any and all grades of stone which contain iron pyrite. Walls built of such stone, no matter how well they look in the outset, are soon striped

Fig. 139.—The Methodist church (engraving reversed), Weeping Water, Neb., showing the result of building structures of stone containing iron pyrite.

and banded, even though the pyrite occurs sparingly. As a rule, our limestones are quite free from this deleterious mineral.

SAND

Large quantities of sand are mined in Nebraska and shipped to the towns of the state, and beyond into Iowa, the annual production at four loading stations in eastern Nebraska being about 6,800 carloads, or 195,000 tons. Thousands of carloads are shipped to Iowa yearly, a single public building at Creston requiring 200 carloads.

The bulk of this is produced in the vicinity of Louisville and Cedarcreek, where the deposit of pure, clean, uniform sand is 35 to 40 feet deep, and the width of the flood-plain of the Platte river, which varies from one to several miles. The supply there is inexhaustible.

The flood-plain of the Platte river has already become the scene of industrial activity in the production of sand and gravel, and it may be foretold with certainty that this re-

Fig. 140.—Example of the use of Dakota Cretaceous sandstone in housebuilding. The old Elder Young house, corner of O and 18th streets, the first stone house in Lincoln, built in 1869 of dressed stone from the Malloy quarry about eight miles north of Lincoln. Shows but little effect of weathering at the end of thirty-three years.

source is sure of greater development. Many of the sand banks along the principal railroad lines are worked out, and future supplies must come mainly from the Platte valley. The sand found there is sharp, clean, and of unlimited amount, and so situated with respect to various railroad lines as to be loaded cheaply by the plow and scraper or steam dredge.

Fig. 141.—Characteristic piece of sandstone of the Dakota formation (Cretaceous). Numerous light spots over the dark rusty surface, along with the imprint of leaves. This rock is used for foundations and occasionally for buildings.

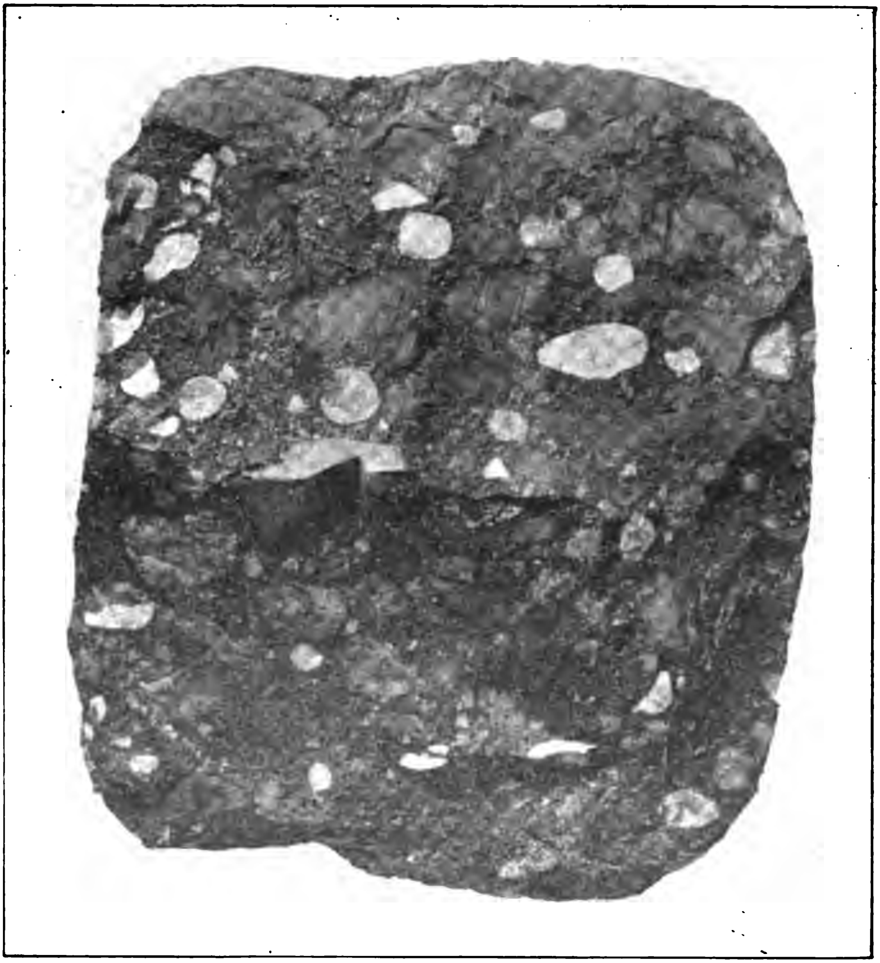


Fig. 142.—Conglomerate, known locally as peanut rock because of its close resemblance to peanut candy of the confectioners, consisting of quartz and jasper pebbles united by a brown iron cement. Louisville gravel pits, Dakota Cretaceous.

The Atwood company at Cedarcreek, which furnishes sand for points along the B. & M. R. R., has operated its sand pits for fifteen years, and though loading some ten cars daily by means of a 35,000-pound dredge, is sometimes two thousand carloads behind its orders.

The Lyman sand company, opposite Louisville, has dredged 40 feet in its sand pits, in supplying points on the Missouri

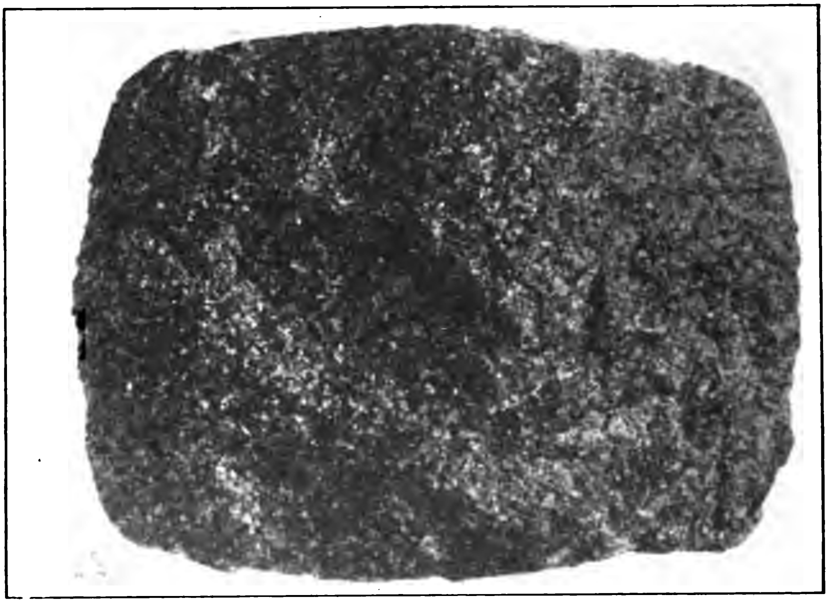


Fig. 143.—Green quartzite of Franklin county, probably of the Ogallala formation. Counted the most beautiful and enduring rock found in the state. The glassy green color is diversified by numerous bits of red feldspar. A few miles south, at Woodruff, in Kansas, this is known as "Woodruff granite."

Pacific railroad; another dredging company at Valley supplies sand for points on the U. P. R. R. These are the points of the greatest production, but there are many others, especially in the Republican valley.

The aggregate production of sand in Nebraska is large beyond all expectation, and the resource is to be described in full by Dr. Condra, to whom the investigation has been assigned.

GRAVEL

Gravel for a great variety of purposes is obtainable over the state, but mostly in the Platte valley, and in the region of glacial drift. The most interesting gravel pits are those near Louisville, in the Dakota formation, where coarse gravel, consisting of well-rounded quartzite pebbles, is obtainable in large quantities. It is used for walks, drives, concrete, tar roofs, etc. Certain hard layers occur in this gravel, constituting the well-known conglomerate called peanut rock, shown in fig. 142.

Fig. 144.—A brick trimmed house in northern Knox county, built of chalk rock sawed while "green" with a common hand saw. Twenty years old and shows but little wear.

A large gravel bed, presumably of glacial origin, found on the Chicago, Rock Island & Pacific railroad near Fairbury, Neb., has furnished large supplies for ballast and other purposes. There are from twenty-five to forty feet of gravel opened up for a distance of several hundred yards. Overlying it is a bed of fifteen to twenty feet of loess, the line of contact being very distinct. See fig. 103.

Our gravel as well as our sand industry will be described in a later report.

FLINT

Many of our beds of limestone are damaged more or less by bands of chert or flint. These occur in the form of nodules and in some places become almost continuous, and it is interesting to note that they are put to good account at last. In the vicinity of Wymore there is an inexhaustible supply of flint. About May 29, 1902, the Atwood Company opened a

Fig. 145.—An industrial scene; B. & M. cars loading crushed flint for ballast. Atwood crusher near Wymore, Neb. This represents a natural resource developed during the year.

quarry about two miles east of Wymore. Their first order was for 50,000 tons of flint ballast for the B. & M. R. R. company. Very little stripping is necessary, and 80 per cent of an eighteen-foot ledge goes to ballast, and 20 per cent to riprap. At the present time they have a large crusher, hoist and screen, employ seventy to eighty men, and produce and ship daily eight to ten carloads of ballast, and one carload

of screenings. It makes an admirable ballast, and it is said that the Union Pacific and other roads have in mind the utilization of this material, which heretofore has been counted a waste product. It can also be put to advantageous use in the construction of city streets. The Geologist would urge the councilmen of towns and cities to give this consideration as a valuable street building material. In recognition of the merits of flint as a road building material, the Hon. Charles

Fig. 146.—Industrial scene on the Burlington & Missouri River railroad near Roca, Neb., showing the use of flint for ballast. Flint heretofore has been a waste product of our quarries. Its use in macadamizing streets is recommended.

H. Morrill has under consideration plans for building the streets and drives at the University farm and Agricultural Experiment station of this material.

In addition to the flint quarries of the Atwood Company, Davis & Mayne, at Blue Springs, have a large quarry which they are developing. The supply seems ample for years to come.

SALT

The salt springs and salt basin at Lincoln used to be a source of salt supply for the West, but no beds like those of Kansas have been or are likely to be found, and since no method of producing salt by evaporation from saline water is as cheap as that of mining it, this industry has ceased to exist. It is safe to say that our numerous deep wells would have revealed salt beds long ago if they existed.

Salt lake was for a while turned to account as a sort of inland summer bathing beach, under the name Burlington Beach, as described on page 107. Salt waters are turned to a still greater account in the Sulpho-saline baths of Lincoln, described on page 108. A considerable amount of salt marsh land was reserved as public land by the state, and still stands unoccupied.

VOLCANIC DUST OR NATURAL PUMICE

Associated with our soils and surface deposits is often found a silvery white powdery mineral, so unlike the soil and other material in which it occurs that it excites the immediate attention of every one. The constant inquiry is, "What is this strange white substance which we find on our farms and ranches?" It seems fitting that a public answer be given to this inquiry. If you ask about the distribution of this powder, or volcanic dust, as it should be called, we would refer you for an answer to the map of the state, fig. 147, on which is shown those counties from which we now have samples in the State Museum. The same volcanic dust occurs in many, if not all, of the intermediate counties, although those only are indicated here which have furnished actual samples. The answer, then, as you will read it for yourselves is that this volcanic dust is found in scattered beds over the entire state. But its real limit extends far beyond and includes western Iowa, South Dakota, Oklahoma, Kansas, Colorado, Wyoming, and Montana and regions farther west. Iowa is plainly its eastern limit, for it occurs very sparingly

and is exceedingly fine, like flour. Going westward through Nebraska it gradually grows coarser, and in Colorado and Wyoming becomes still coarser and less white until it is ash-colored. The beds, which are thin to the east, grow thicker to the west, the maximum being reached in Huerfano county, Colorado, where the reported thickness is as much as 400 to 600 feet. It is often called volcanic ash, which is applicable and is descriptive of its appearance, and is correct enough if you will remember that it is not the product of combustion like ash on the hearth, but is instead shattered

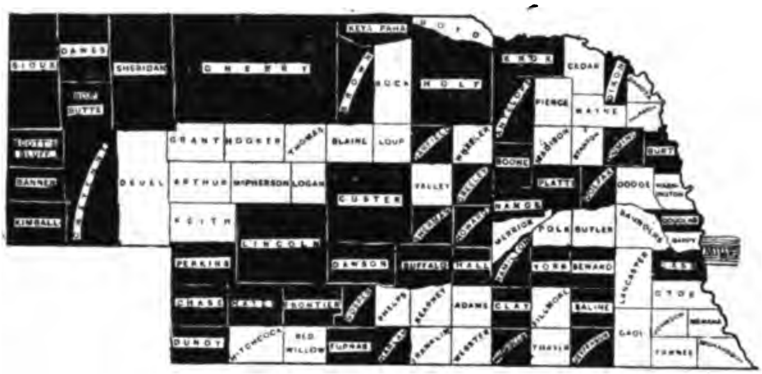


Fig. 147.—A map showing the present knowledge of the distribution of volcanic ash in Nebraska. Only those counties are shaded which have furnished actual samples of ash. It doubtless occurs in the intermediate counties.

volcanic rock, or pumice. This fact has given rise to the name, natural pumice, which is particularly appropriate. Unfortunately, the nature of the substance and its origin were misunderstood by the first writers who described it, hence it often goes by the misleading name "geyserite," although in fact it has not the remotest relation to geysers. In addition, it has a number of trade names under which it is sold, such as Gibson Grit, Diamond Polish, etc. This natural pumice is very like the powdered pumice of the stores. Both come from block pumice, which is "volcanic froth" or natural glass. In the one case the blocks are ground up by machinery, in the other they are ground up by the violent

volcanic explosions, which carry the dust high into the air, whence it is transported over the land for hundreds of miles around. The origin of all this volcanic dust, though not located, is evidently far to the southwest of our state. The question naturally arises, why is not our native pumice as good as the imported pumice? Ours costs about $2 a ton, while the imported article may cost ten to fifteen times as

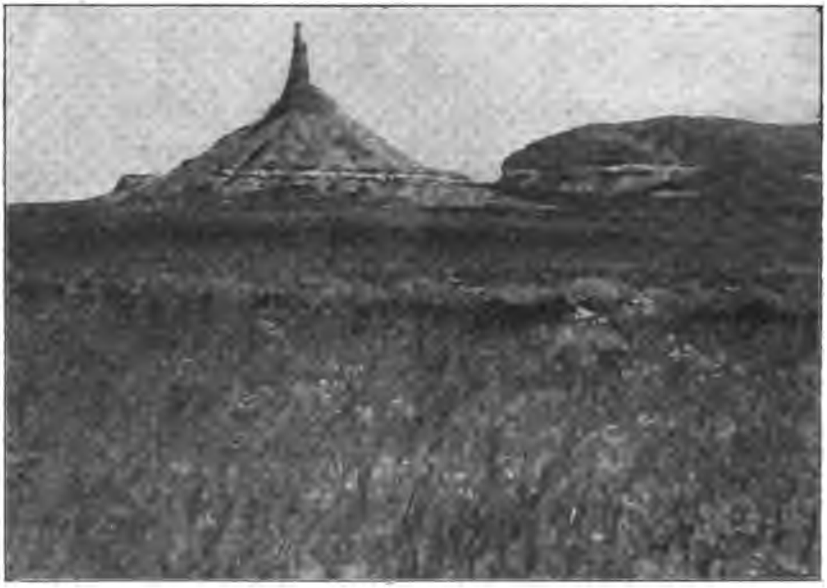


Fig. 148.—Chimney Rock, near Gering, Scotts Bluff county, Nebraska, showing a white band of volcanic ash near the base, some four or five feet in thickness. Chimney Rock is one of the landmarks best known to the pioneers.

much. As compared with the foreign pumice, ours is quite as pure, and often freer from silt and foreign matter. The trouble seems to be that our natural pumice is more glassy and occurs in flat scales. It lacks the minute bubbles, tubes, vesicles, and sharp polishing points of the foreign product. Hence it is not so good an abrasive, or polishing powder. However, our natural pumice varies greatly in this respect, and it is not at all unlikely that, if the five carloads recently

tested in Chicago had been selected with reference to these principles, the test would have been satisfactory. It does seem that a deposit so generally distributed over the state

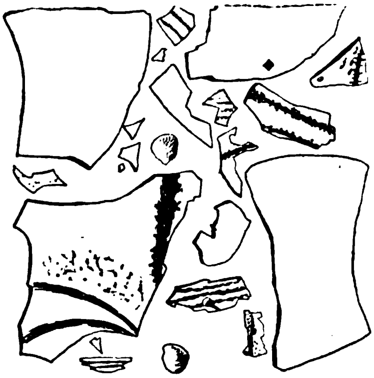


Fig. 149.—Coarse volcanic ash from Chase county, Neb., nearly pure.

Fig. 150.—Coarse volcanic ash from Hayes county, Neb., as seen under the microscope.

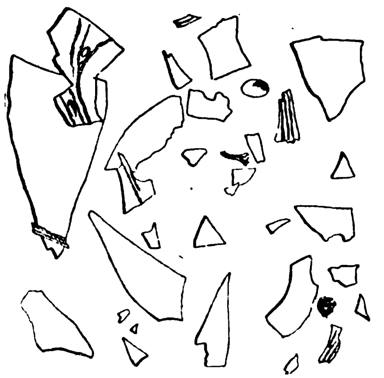


Fig. 151.—Volcanic ash from Harlan county, Neb., as seen under the microscope. The bulk of volcanic ash has been furnished to the market by this county.

Fig. 152.—Volcanic ash from York county, fine and nearly pure.

should have many uses, and that this natural resource may yet be developed to advantage. At present it is used for polishing and scouring kitchen ware, and as a base for scouring

soap, and it is estimated that the entire amount sold annually in Nebraska amounts to but four or five thousand dollars. Local dealers in almost every town put it up in packages and sell it under various names, while three soap firms, one in Denver, one in Omaha, and one in Burlington, Iowa, use large amounts. It has been shipped as far east as New York and Philadelphia, and inquiries come from many eastern cities concerning it. Its chemical composition, according to analyses by Prof. H. H. Nicholson, of the Department

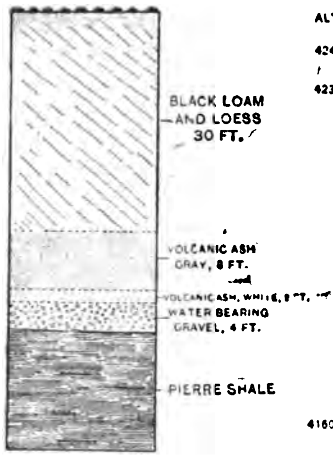


Fig. 153.—Section in Harlan county.

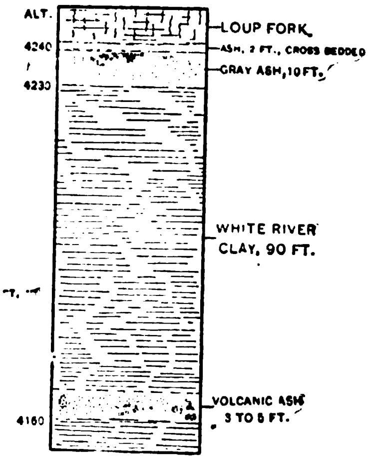


Fig. 154.—Section in Scotts Bluff county.

of Chemistry of the State University, is as follows: Organic matter, 8.75 per cent; SiO_2, 68.91 per cent; CaO, 3.44 per cent; Na_2O, 3.09 per cent; K_2O, 0.36 per cent; SO_2, 8.88 per cent; Fe_2O_3 and Al_2O_3, 6.12 per cent; total, 99.55 per cent.

Geologically this deposit seems to be confined to the more recent layers, and has not been found below the Oligocene, but does occur in beds of varying thickness and extent from that point up to the latest formations.

ANALYSIS OF HARLAN COUNTY ASH

(From Merrill's Rocks, Rock-Weathering, and Soils)

CONSTITUENTS	PER CENT
Silica (SiO_2)	69.12
Alumina (Al_2O_3) } Iron Oxide (Fe_2O_3) }	17.64
Lime (CaO)	0.86
Magnesia (MgO)	0.24
Potash (K_2O)	6.64
Soda (Na_2O)	1.69
Sulphuric acid (SO_3)	....
Water and volatile matter lost on ignition	4.05
	100.23

ANALYSIS OF VOLCANIC ASH FROM HARLAN COUNTY, NEBRASKA, MADE BY R. S. HILTNER, DEPARTMENT OF CHEMISTRY, THE UNIVERSITY OF NEBRASKA

	PER CENT
Silica (SiO_2)	71.56
Iron and alumina oxide (Fe_2O_3–Al_2O_3)	15.04
Calcium oxide (CaO)	1.19
Magnesium oxide (MgO)	0.49
Sodium and potassium oxides (Na_2O and K_2O)	5.51
Sulphuric anhydride (SO_3)	0.73
Water and volatile matter lost on ignition	5.48
	100.00

LIST OF PAPERS CONCERNING VOLCANIC DUST IN NEBRASKA

1. Samuel Aughey. Sketches of Physical Geography and Geology of Nebraska. 1880, pp. 238 to 241.

2. M. E. Wadsworth, M. D. Lithological Studies. November, 1884, p. 17.

3. George P. Merrill. *National Museum Proceedings.* April 2, 1885, vol. 7, p. 99.

4. Peales. Lacustrine Deposits of Montana. *Science,* August 20, 1886.

5. George P. Merrill. *American Journal of Science,* September, 1886.

6. George P. Merrill. *American Journal of Science,* September, 1886, pp. 199 to 204.

7. George P. Merrill. Notes on the Composition of Certain Pliocene Sandstones from Montana and Idaho. *American Journal of Science,* vol. 32, September, 1886.

8. L. E. Hicks. Geyserite in Nebraska. *American Geologist,* vol. 1, 1888, pp. 277 to 280.

9. L. E. Hicks. *American Geologist,* 1888, vol. 2, p. 64.

10. George P. Merrill. *American Geologist,* 1888, vol. 2, p. 437.

11. L. E. Hicks. *American Geologist,* 1888, p. 437.

12. J. A. Udden. On a Natural Formation of Pellets. *American Geologist,* vol. 11, April, 1893.

13. E. H. Barbour. Abstract *Proceedings of the Nebraska Academy of Science,* no. 5, December, 1895, 4 pp., 11 figs.

14. F. W. Cragin. Pearlette Ash. Colorado College Studies, vol. 6, p. 54, March, 1896.

15. R. D. Salisbury. Volcanic Ash in Southwest Nebraska. *Science,* December 4, 1896.

16. J. E. Todd. *Science,* pp. 61, 62, January 8, 1897.

17. F. M. Haworth. Geological Survey of Kansas, vol. 2, 1897.

18. E. H. Barbour. The Deposits of Volcanic Ash in Nebraska. *Annual Report of the State Board of Agriculture,* 1896, pp. 232 to 238, 11 figs.

19. E. H. Barbour. Notes on the Ash Beds of Nebraska and the Great Plains. *Mineral Industry,* vol. 6, 1898, pp. 22 to 27, 5 figs.

20. E. H. Barbour. Volcanic Ash in Nebraska Soils. *Annual Report of the State Board of Agriculture,* 1902, pp. 239 to 242, 6 figs.

NATURAL GAS

Natural gas has been reported from a number of wells, and from many marshes and pools, but this is without significance; in the wells it soon ceased, and natural gas is being generated in every stagnant pool. There is significance in

the fact that deep wells have all but demonstrated that natural gas is not to be expected; still there is not a year goes by without many attempts to get gas by drilling.

PETROLEUM

The discovery of petroleum is often reported in the hopeful headlines of county papers, but in every case, as far as can be learned, the scum or film of oil proves to be an irridescent film of iron instead. Iron water on coming to the surface suffers from the oxidizing action of the air, and a film of iron exactly resembling oil is formed. From Rock county a specimen of sand rock saturated with oil has been received, and from Brown county come authentic reports of small amounts of oil having been collected and preserved in bottles. This is mentioned more as a matter of interest than as one of prospective utility.

THE SOILS OF NEBRASKA

Since Nebraska stands as the most distinctly agricultural state in the Union, its soils must rank as a natural resource of profound importance, and worthy of the utmost development. It seems the more ironical, then, that so much time and attention should be paid to the development of mines, when our agriculture yields annually more gold than all the combined gold and silver mines of the United States. The soil is literally inexhaustible, and there is no predicting what may not result from the full development of our agricultural resources.

There are several well-defined, broad soil areas, and others much more restricted in extent and not generally known. Our western soils are native soils, resulting from the rotting and breaking down of native rocks, while our eastern soils are transported soils, some having been carried glacially from regions five hundred to six hundred miles to the north, and dropped by the melting of the ice.

In general, the soils of a region correspond to its geological divisions, but there are exceptions here because of the

depth to which many of our rocks are buried. The eastern fifth, or the glaciated portion, constitutes a region of drift soil where not covered by loess. The southeastern half of Nebraska is almost wholly a region of loess soil. The sandhills constitute another soil region of broad extent, with one tongue of sand extending well to the northeast, and two tongues extending to the extreme southwest. Scattered through the sandhills, and occurring in large tracts further west, is a soil characterized as one digs downward by increasing amounts of lime and lime pebbles, known as magnesia soil. This soil region corresponds with the magnesia rock, or the Ogallala formation. The writer is frequently consulted about this same magnesia soil, which is viewed with distrust by many.

A lime soil is counted a productive soil, and experience shows our magnesia soil to be particularly so. About all it lacks is moisture. Under irrigation it is very productive.

The western counties constitute a soil region which may be called butte soil, characterized by fine sandy soil and ample lime. The soil of this region is derived from the breaking down of Arikaree or Butte sand. With ample rainfall this, too, is highly productive.

Throughout the West, and more particularly the Northwest, are scattered tracts of Bad Lands which constitute another soil area. In the region of shales, especially the Pierre shale, are tracts known as gumbo soil. Along the river courses, most noticeably the Platte, are broad, level tracts of alluvial soils. In certain places there are alkali soils, due chiefly to imperfect drainage. The area of salt land soil is too restricted to be mentioned, being confined to Salt creek and the salt marshes near Lincoln.

THE MECHANICAL ANALYSES OF THE SOILS OF NEBRASKA

Under the auspices of the State Board of Agriculture and the State Geological Survey, the writer undertook, in 1892, the work of collecting the soils of the state, both for permanent display in the State Museum and for the more technical purposes of analysis.

Ordinarily, it is sufficient to collect the soils from a few typical regions, but where the state is unusually large, and where the counties are correspondingly large, and their citizens zealously interested in their respective counties, it has been the attempt to have each and every county in the state represented. The soil survey will be counted unfinished until this is done. A county line is a purely artificial and arbitrary boundary, yet there is reason to regard it in making the soil survey.

In spite of the old and well-established saying that the judgment of a good farmer is to be relied upon in the selection of a good soil, rather than the analysis of an experienced chemist, yet the importance of the chemical determination of soils in the United States has grown in popular recognition to such an extent that the government has devoted a special department to this particular research, with the result that the old saying is all but disqualified.

In many regions it is a matter of national importance to determine the nature of cotton soils, tobacco soils, truck soils, sugar beet, wheat, and corn soils; to determine chemically what they lack of fulfilling the requirements and what can be done for their improvement; and when they are worn out or overtaxed, to determine means for their reclamation or betterment, as the case may be. All of this can be determined by geological and chemical methods.

In Nebraska the need of such exact determination is less conspicuous than in some of the less fortunate states, for the reason that our soils are particularly deep, and have all the elements of fertility; accordingly, it is not so essential that the chemist should determine for us the question of fertility and fertilizers. That seems to have been settled for us by a very bounteous nature. Nevertheless, as we come into closer agricultural competition, and are brought, little by little, to more diversified agriculture, it is plain that good must come out of a fundamental knowledge of our soils and the amount and kind of their constituents. Such a knowledge comes in one way, and one way only;

that is, through the methods of the laboratory. All other methods are matters simply of good judgment; they are mere guesses, and are altogether superficial, answering the purposes of a particular farm, but throwing no light on the soil

	Per cent.
Organic matter 4.0, Moisture 3.5	7.5
Medium and coarse sand and gravel	3.5
Fine sand	7.5
Very fine sand	36.0
Very fine silt 4.0, and silt 27.0	31.0
Clay	14.5

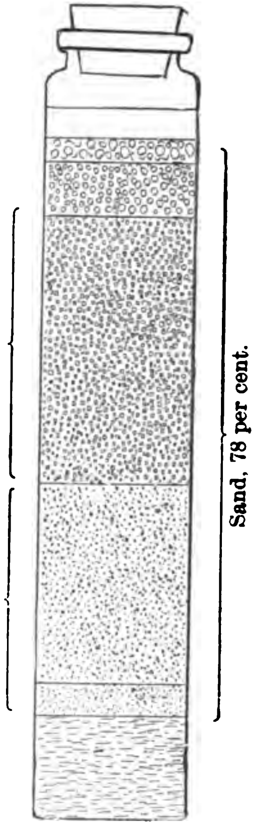


Fig. 155.—Showing an average Nebraska soil based on the mechanical analysis of 85 soils. Though an approximation, this is sufficiently accurate to show about what the constituents of an average soil are, sand being the main one.

conditions of a community, nor obtaining results which might tend to the betterment of the soil and crop conditions of a commonwealth.

The work of soil collecting was greatly stimulated by the International Fair, the Columbian Exposition at Chicago in

1893, and again by the Trans-Mississippi and International Exposition at Omaha, in 1898. In both instances the soils of our state were to come into close comparison with those of other states, older and better represented. For a young state, with so much land yet to be occupied, and so many favorable or unfavorable impressions to be conveyed, it seemed worth while to put forth especial efforts in this direction, the result being that no better showing was made at either of the great expositions, and very substantial awards were received. It is believed that no state in the Union has a larger or more representative collection of soils than Nebraska, and there are many yet to be added. It is necessary, in some cases, to take more than one sample from a county in order to fairly represent it. Some counties are characterized by sandhills in one part, and rich valley soils in another. One soil sample might, therefore, show the soils of that particular county in a false light. Sometimes there are clayey uplands and sandy bottoms; here again, to make it representative, two, or sometimes three, samples must be taken.

This explanation is necessary, because, though the soil survey of the state is well begun, yet, as the writer plans it, it will not be done in fact until all soil conditions of every county in the state are as fairly represented as possible.

If we make a composite soil, by striking the average of all the soils as far as analyzed, the result will be about as shown in the bottle. The clay will equal about 14.5 parts; silt and very fine silt, about 31 parts; very fine sand, 36 parts; fine sand, 7.5 parts; medium sand, coarse sand, and gravel, 3.5 parts; organic matter, 4 parts; moisture, 3.5 parts. See fig. 155.

The state is indebted to Prof. Milton Whitney, of the United States Department of Agriculture, for the following analyses:

SUMMARY OF MECHANICAL ANALYSES OF SOILS AND SUBSOILS OF NEBRASKA

FIGURES SIGNIFYING COLLECTORS' NAMES

1. Hon. Robert W. Furnas, Brownville, Neb.
2. Mr. Milton Whitney, Washington, D. C.
3. Mr. Robert Hay.
4. Dr. George L. Miller, Omaha, Neb.
5. Mr. Carl Morton, Nebraska City, Neb.
6. Youngers & Co., Geneva, Neb.
7. Mr. J. P. Holloway.
8. Mr. G. D. Swezey, University of Nebraska.
9. Mr. Erwin H. Barbour, University of Nebraska.

Number of analysis	LOCALITY — COUNTY	LOCALITY — TOWN	Moisture in air-dry sample	Organic matter	Gravel 2-1 mm.	Coarse sand 1-.5 mm.	Medium sand .5-.25 mm.	Fine sand .25-.1 mm.	Very fine sand .1-.05 mm.	Silt .05-.01 mm.	Fine silt .01-.005 mm.	Clay .005-.0001 mm.	Collector.
			%	%	%	%	%	%	%	%	%	%	
418	Adams ..	Hastings	3.24	5.98	0.00	0.00	0.03	0.11	10 43	55.14	7.50	16.45	8
1440	Adams ..	Hastings	5.71	4.31	0.00	0.00	0.02	0.32	27.79	42.89	1.09	17.67	9
1843	Antelope	....	4.33	6.73	0.00	0.00	0.05	1.28	46.19	25.06	4.38	12.42	1
2085	Blaine...	Dunning ...	0.46	0.76	0.00	0.12	3.28	70.05	22.29	1.14	0.23	2.12	9
2105	Boone ...	Cedar Rapids	2.81	3.20	0.00	0.00	0.26	2.27	58.07	11.26	2.37	20.83	9
2079	B'xButte	Alliance.....	2.91	4.64	0.17	0.28	1.77	5.15	43.48	20.54	1.73	20.63	9
2117	Buffalo..	Ravenna	2.55	2.90	0.00	0.07	0.40	4.22	49.01	27.93	1.53	11.43	9
2113	Butler...	Millerton ...	4.17	4.82	0.00	0.00	0.04	0.19	36.37	23.47	4.70	26.70	9
1812	Cass.....	....	4.90	5.30	0.00	0.00	0.00	1.10	12.07	54.25	9.00	12.35	1
2073	Cass.....	Weep'g Wtr.	4.19	5.80	0.00	0.05	0.07	0.20	24.35	39.47	3.58	23.82	9
1492	Cedar ...	Hartington..	2.72	3.31	4.39	8 69	15.88	11.48	13 23	32.47	3.29	4.70	9
686	Cheye'ne	....	0.41	0.66	0.00	0.16	14.48	64.61	17.49	0.09	0 28	1.12	9
1617	Cheye'ne	....	5.51	9.53	0.00	0.07	0.16	1.46	31.21	33.64	2.89	18.02	7
2089	Custer ..	Merna.......	2.80	2.82	0.00	0.00	0.02	3.97	59.47	15.73	1.45	14.40	9
2077	Dawes ..	Crawford ...	1.59	2.70	0.07	0.32	1.22	12.65	71.31	3.57	0.64	6.95	9
416	Deuel....	Big Spring..	0.16	3.06	2.03	1.30	5.14	17.58	41.35	14.03	1.52	13.00	8
682	Deuel....	....	0.26	1.13	0.00	0.00	19.70	69.00	6.95	0.31	0.51	2.35	9
1797	Deuel....	Chapel	1.93	3.43	0 04	0.05	1.26	15.83	55.97	10.72	3.31	7.17	3
1800	Deuel....	Big Spring..	2.54	3.32	0 00	0.00	0.04	0.50	74.85	9 44	1.93	8.00	3
1801	Deuel....	Big Spring..	2.19	2.81	0.00	0.00	0.04	0.35	76.25	13.28	1.19	4.81	3
1808	Deuel....	Big Spring..	3.17	3.47	0.55	0.26	0.83	4.35	40.45	21.42	7.30	18.92	3
1809	Deuel....	Big Spring..	4.00	2.16	0.00	0.00	0 00	2.08	47.63	32.54	3.86	6.68	3
2809	Deuel....	Big Spring..	2.71	3.41	0.00	0.00	0 00	2 40	72.87	13.68	1.93	4.63	3
1915	Douglas .	Seymour Pk	3.09	7.40	0.00	0.00	0.00	0.00	0.00	57.32	8.15	25.65	4
1916	Douglas .	Seymour Pk.	2.59	7.54	0.00	0.00	0.00	0.00	0.00	61.36	5.61	24.37	4
393	Dundy ..	Benkelman..	0.70	6.10	0.00	0.00	1.45	4.90	62.00	8.89	2.32	17.75	8
395	Dundy ..	Benkelman..	0.76	3.86	0.00	0.14	1 67	6.83	69.11	6.04	0.87	11.10	8
1794	Dundy ..	Benkelman..	0.70	1.60	5.90	6.15	14 40	14.60	36.05	7.56	1.46	11.37	3
1795	Dundy ..	Benkelman..	2.10	2.86	0.09	0.05	0.18	0.63	67.55	15.79	2.72	9.50	3
1467	Fillmore	Fairmont....	6.21	4.97	0.00	0.00	0 00	0.40	20.84	46.12	1.21	21.34	9
1670	Fillmore	Geneva......	3.92	7.68	0.00	0 00	0.00	0.43	12.75	59.17	5.12	10.87	6
1671	Fillmore	Geneva......	3.91	6.82	0.00	0.00	0.00	0.35	14.62	52.87	4.76	15.45	6
1865	Fillmore	Geneva......	4.63	2.39	0 00	0.00	0.05	0.56	23.87	40.51	5.55	22.35	2
1866	Fillmore	Geneva......	3.11	5 54	0.00	0 00	0 00	0.00	13.99	36.99	4.69	35.83	2
1869	Fillmore	Geneva......	1.63	3.97	0.00	0.00	1.36	1.92	28 19	30.59	4 33	28.55	2
1868	Fillmore	Geneva......	1.72	6.58	0.00	0.00	0.70	1.87	33 04	39.54	5 31	11.24	2
1820	Gage	Beatrice....	5.96	6.40	0.00	0.00	0.00	2.30	12.91	43.47	12 16	17.15	9
2083	Garfield .	Burwell	1.92	2.02	0 58	0.62	2.36	16.75	55.47	5.90	0.87	14.43	9
1490	Gosper ..	....	3.60	3.20	0.00	0.00	0.00	0.92	19.37	62.31	3.21	10.00	9
2107	Greeley .	Troy	2.16	2.28	0.00	0 00	0.24	1.81	73.91	6 65	1.57	12.28	9
2111	Hall	Abbott	0 63	1.14	0.15	1.23	12.89	52.24	23.26	3.39	0.41	5.28	9
2093	Hamilt'n	Aurora	4.19	4.26	0.00	0 00	0.02	0.13	35.26	28.05	5 94	23.15	9
1838	Harlan ..	Alma	2.50	2.82	0 00	0 00	0.00	0.00	44.52	33.56	3.41	11.62	1
1841	Harlan ..	Repub. City.	5.13	5.22	0.08	0.30	0.15	.70	29 95	36.58	6.51	15.40	1
389	Hitchc'k.	Culbertson..	0.24	7.92	0.00	0.00	0.00	0.05	53.05	15 49	3.49	23 10	8
391	Hitchc'k.	Culbertson..	1.46	5 88	0.00	0.00	0 00	0.17	48.87	19.01	5.09	19 05	8
2101	Hooker ..	Mullen	0.61	1.05	0 00	0.41	8 59	45.62	39.56	0.86	0.28	3 35	9
2081	Howard .	St. Paul.....	0.92	1.68	1.21	3.34	18 49	39.45	23.29	5.76	0.72	5.65	9

SUMMARY OF MECHANICAL ANALYSES—*Continued*

Number of analysis	LOCALITY: County	LOCALITY: Town	Moisture in air-dry sample	Organic matter	Gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Fine silt	Clay	Collector
					2-1 mm.	1-.5 mm.	.5-.25 mm.	.25-.1 mm.	.1-.05 mm.	.05-.01 mm.	.01-.005 mm.	.005-.0001 mm.	
			%	%	%	%	%	%	%	%	%	%	
1828	Jefferson	Fairbury	6.06	6.10	0.00	0.00	0 CO	3.16	16.46	41.73	9.48	16.77	9
1798	Keith ...	Ogallala.....	1.63	2.63	0.02	0.03	0.10	6.11	78.26	5.77	1.69	4.05	3
1804	Keith....	Ogallala.....	2.00	2.18	0.00	0.00	0.00	2.25	68.60	19.27	1.70	3.45	3
1803	Keith....	Ogallala.....	2.01	2.03	0.00	0.00	0.03	1.95	75.58	12.93	1.31	4 22	3
1840	Kearney.	Minden	4.38	5.31	0.03	0.00	0.26	0 87	37.93	25.98	7 66	19.05	9
3242	Lancastr	Lincoln	5.95	6.37	0.00	0.02	0.11	0.43	23.60	34.22	7.10	24.05	8
3243	Lancastr	Lincoln	8.09	4.30	0.00	0.02	0.09	0.37	17.73	30.16	8.13	32.82	8
422	Lincoln..	North Platte	0.11	4.06	0.08	0.13	0.88	6.04	66.64	8.93	2.60	9.90	8
2103	Loup	Taylor	2 46	2.38	0 04	0.15	2.00	8.36	63.45	7.37	1.63	13.70	9
1814	Madison	....	4.90	3.80	0.00	0.00	0.00	0.36	10 47	49.52	9 88	20.60	3
2109	Merrick.	Palmer	1.84	1.70	0.00	0.19	3.94	33.69	39.26	6.11	1.36	12.33	9
2097	Nance...	Belgrade	3.04	3.19	0.00	0.00	0.06	0.90	55.96	19.56	2.43	16.10	9
1712	Nemaha.	....	5.86	3.39	0.00	0 00	0.0o	0.42	25 92	40.98	3.70	19.32	1
1713	Nemaha.	....	7.60	2.54	0.00	0.00	0 00	0.60	26.32	40 82	3.65	17.64	1
1714	Nemaha.	....	4.38	4.72	0.00	0.00	0 00	0.12	28.70	49.30	2.33	10.30	1
1715	Nemaha.	....	3.82	4 54	0.00	0.00	0 00	0.10	25.83	54.47	2.53	9.49	1
1716	Nemaha.	....	4.12	2.18	0 00	0.00	0 00	0.00	23.52	56.67	2.31	10.35	1
1717	Nemaha.	....	5.40	4.96	0.00	0.00	0.00	0.00	23.14	54.81	2.46	9.45	1
353	Otoe.....	Nebr. City..	6.62	4.53	0.00	0.00	0.28	0.90	15.23	42.15	7.52	21.93	5
349	Otoe.....	Nebr. City..	7.92	5.11	0 00	0.00	0.04	0.18	16.10	38.40	9.48	22.17	5
351	Otoe.....	Nebr. City..	7.72	4.86	0.00	0.01	0.06	0.58	18.22	36.87	8.14	24.34	5
2071	Otoe.....	Syracuse	5.52	4.86	0.01	0.01	0.11	0.52	19.87	35.35	4.99	29.73	9
1805	Perkins .	Venango	1.13	4.62	10.31	6.28	11.28	18.47	36.36	7.73	1.97	1 44	3
1806	Perkins .	....	0.85	4.12	2.10	4.66	11.64	15.44	45.94	4.71	0.98	9.02	3
1438	Perkins .	Grant	4.28	3.35	0.22	1.52	5.34	7.56	36.71	28.21	0.34	11.06	9
2091	Perkins .	Grant	0.70	0.80	0.00	0.00	5.06	51.18	38.00	0.40	0.12	3.40	9
1436	Phelps ..	Holdrege....	5.67	4.10	0.00	0.00	0.03	0.14	22.97	44 95	1.04	22.02	9
1832	Phelps...	Holdrege....	4.75	4.75	0.00	0 00	0.00	0.00	41 40	28.00	5.86	14.80	1
1819	Polk.....	Osceola......	2.90	7.32	0.00	0 00	0.00	0.00	20.48	48.72	7.47	12.95	9
2087	Saline ...	Crete	4.88	4.68	0.03	0.02	0.06	0.15	26.81	35.50	3 23	26.20	9
2075	Saunders	Valparaiso ..	2.94	4.08	0.27	0.80	4.39	17.37	36.05	13 50	3.33	18.90	9
1830	Scotts B.	....	5 00	2 50	0.00	0.00	6.00	12.64	46.02	14 93	5.51	8.60	1
2095	Sherman	Litchfield ...	1.84	2 26	0.00	0.08	1.66	20.89	52.97	6.95	1.36	13.02	9
1829	Sioux....	Harrison	4.60	6.80	0.00	0.00	0.00	2.30	59.96	17.84	3.11	6.35	1
2099	Thomas .	Seneca	1.17	2.04	0.08	1.15	8.20	40.07	39.17	2 98	0.63	5.05	9
1471	Thurst 'n	Pender	4.1J	6.60	0.00	0.00	1.25	3.22	8.58	46.88	10.32	17.77	9
2115	Valley ..	Ord	2.15	2.57	0.72	1.45	8.20	17.90	40.06	10 49	1.52	15.60	9

A FEW BOOKS ON SOILS

Every progressive farmer will find himself at once interested and instructed by perusing some plain treatise on the origin and nature of the soil—the very foundation on which agriculture is laid. Accordingly, he should surely have one or more such works upon his shelf. The writer would recommend to the farmers of Nebraska that most admirable little book by King, entitled The Soil. It is simple, yet scientific. Though short, it is long enough to show clearly the relation of things. There are also many other good works. A few of the less technical are mentioned below:

1. Soils and Crops of the Farm, by George E. Morrow and Thomas F. Hunt, in the Farmers' Reading Circle Library—about 300 pages. 2. First Principles of Agriculture, by Edward B. Voorhees, treating of soil fertilizers, crops, animal food, principles of breeding, etc.—about 200 pages. 3. The Origin and Nature of Soils, by N. S. Shaler, of the United States Geological Survey. Twelfth Annual Report, 1890–91, part I, pp. 213 to 347. 4. Rocks and Soils, by H. E. Stockbridge; a chemical, geological, and agricultural treatise. 5. Rocks, Rock-weathering, and Soils, by George P. Merrill; a more exhaustive treatise than any of the foregoing. It is really a text-book for colleges, containing, nevertheless, much that is instructive to the farmer as well as those versed in technical practice—about 400 pages.

LIST OF PAPERS TOUCHING NEBRASKA SOILS, SOIL MOISTURE, ETC., PREPARED FOR THE STATE BOARD OF AGRICULTURE

1. Soils—Report of the Geologist, 1894. 2. Progress Made in the Soil Survey of Nebraska—Report of the Geologist, 1895. 3. The Problem of Our Soils and Soil Moisture—Report of the Geologist, 1896. 4. The Value of Water as a Soil Element—Report of the Geologist, 1897. 5. A Preliminary Report on the Mechanical Analyses of the Soils of Nebraska.

NATIVE PLASTER

A number of communities produce a native plaster with which houses are successfully and very cheaply plastered. However, the writer is unable to recommend it for use, because of the readiness with which it breaks down when wet. Certain ledges in the Arikaree and Ogallala yield a fine grained, sandy rock which is quarried for plaster. This rock, which consists essentially of very fine sand, or silt, united by clay and lime, slacks, as it is called, very quickly when placed in water. This is mixed with four parts of sand to one part of the native mortar, and is applied directly to the laths. It is hard and takes a skim coat and lasts, according

to all accounts, for years. Tests were made on a number of cubes of this native plaster properly cast and dried, and gave the following results:

The compression test on a cube 0.9 inches square gave 200 pounds. When mixed with hair, it withstood a pressure of 235 pounds. In the tension test an inch square briquet of the native plaster, without hair or fiber, stood a tension of 75 pounds.

This native plaster is plainly harder and better than much cheap plaster which goes on many walls, and costs nothing to those living near the source of supply, but it will not bear moisture. Any leak in the roof or exposure to water ruins the plaster almost instantly. One of the cubes, such as had been used in the pressure tests, when plunged in water was reduced to fine mud within two minutes. Several attempts have been made to put this plaster upon the market, and hopes are still entertained that it may yet be done, but in its present form it is not to be considered a resource worthy of development.

CONCRETIONARY FORMS

Throughout the claystones, limestones, and sandstones of any region it is a common occurrence to find a great variety of concretionary forms which excite inquiry. Without entering into technicalities, it may be explained that concretionary structure generally results from mineralization around some center. Hence, a concretion is generally round in outline and harder than the surrounding rock. Accordingly, when the mother rock rots down, numerous balls of various sizes and shapes are left behind, some being solid, others more or less hollow. It is quite a common occurrence to find pyrites of iron crystallized into balls, as seen in plate VIII, figs. 1, 2, and 3. In the loess, or "yellow clay," irregular lime balls, such as appear in figs. 11, 12, and 13, plate VIII, are almost universally present. Sand is often cemented into concretions ranging in size from peas to cannon balls. A sand concretion, such as is very common in Sioux county,

is shown in plate VIII, fig. 7. In Cheyenne county, pyrolusite, or oxide of manganese, concretes into balls, as shown in figs. 9 and 10, plate VIII, fig. 10 being a specimen broken open to show the radiate structure. Sometimes the concretions or balls break in various directions on shrinking, and the cracks subsequently become filled with some hard mineral.

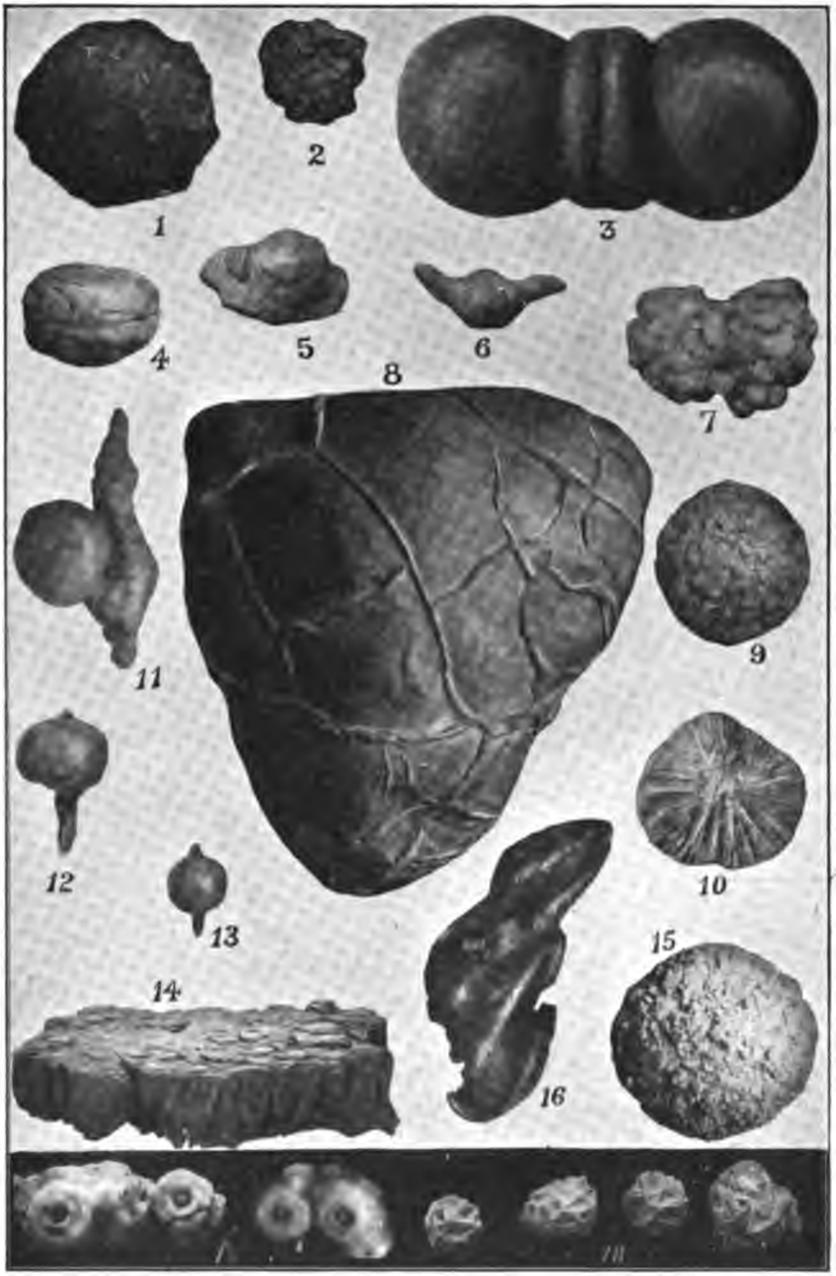
These concretions are very abundant and often of gigantic size in shale. A specimen of this sort from the Carboniferous, presented to the State Museum by Hon. Robert W. Furnas, is shown in plate VIII, fig. 8. Its form, though like that of a heart, is purely imitative. So closely do certain concretions imitate many living things that people are excusable for being deceived. In the dry stream beds of the Bad Lands one encounters trains of clay balls often studded over with bright colored bits of rock and pebbles, as shown in plate VIII, fig. 15. These not infrequently are as much as two feet in diameter, and result from detached pieces of tough clay being rolled down stream during a sudden storm. In the same region there are great numbers of lime balls resulting from the crystallization of lime in the Bad Land clays. Four such calcite balls are shown in fig. 18, plate VIII.

In the same plate, in fig. 17, two stalactitic forms of chalcedony are shown. In our limestones and clays, a structure called cone-in-cone is common. Fig. 14, plate VIII, represents a specimen from quarries near Fairbury, Neb., in the

---

EXPLANATION OF PLATE VIII

1. Pyrite nodule, showing corner of cubes
2. Marcasite nodule, Scotts Bluff county
3. Pyrite concretion, unusual form, Plattsmouth, Neb.
4, 5, 6. Pyrite nodules, Table Rock, Neb.
7. Sand concretion, Sioux county
8. Septarium, "pine apple" concretion, Brownville
9. Ball of pyrolusite, Cheyenne county
10. Same broken to show radiate structure
11, 12, 13. Loess concretions
14. Cone-in-cone, Fairbury, Neb.
15. Clay ball and pebbles formed by rolling, Sioux county Bad Lands
16. Two-ounce nugget of native copper, Cheyenne county
17. Chalcedony, Cheyenne county
18. Calcite balls, Sioux county Bad Lands



MISCELLANEOUS CONCRETIONARY FORMS

Dakota formation. Hollow spheres, sometimes beautifully lined with crystals, are abundant and are called geodes. Descriptions of all of these forms may be found in text-books of geology.

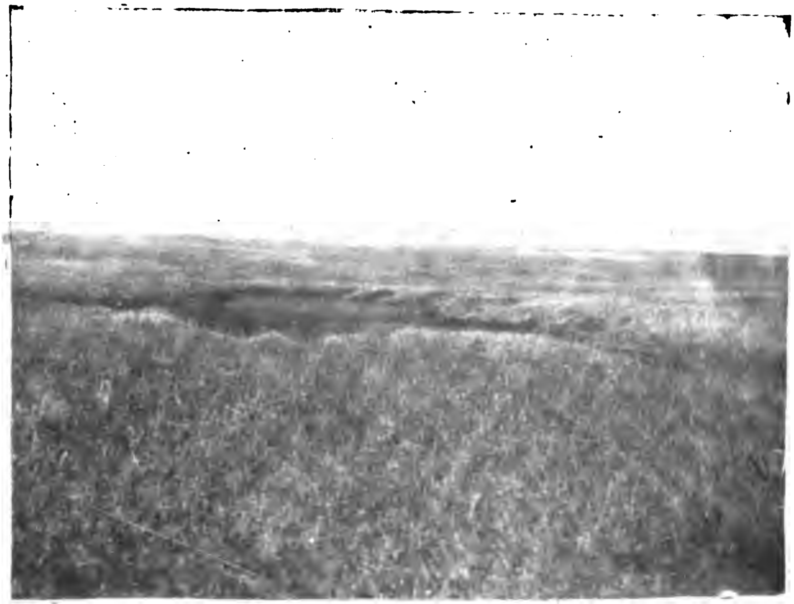


Fig. 156.—A 1-acre buffalo wallow, Pine Ridge, Sioux county, Neb.

GEYSERS AND VOLCANOES

At one time it was believed that extensive geysers existed in Nebraska, and the idea survives in "geyserite," the name first applied to our volcanic ash. Strangely enough, this theory was defended by several geologists. Geyserite soap, made in Denver of volcanic ash shipped from Harlan county, owes its name to the same error. Geyserite is wholly unlike volcanic ash in all respects; they bear no relation to one another, and the idea is the result of a misconception. There is nothing akin to geyserite in the state.

At Ionia, Dixon county, is found the "volcano," or "burning hill." Though said to be declining in activity, this hill was once an object of considerable interest, especially after

freshets in the Missouri river. Though not visited, the smoking or steaming seems to be due to the decomposition of pyrite in the damp shales. It seems that sufficient chemical heat is produced to make the hill-top steam and even to fuse some of the sand and clay. It bears no relation whatever to a volcano.

A List of Papers on the Natural History of Nebraska

Botany, geology, and zoology are so inseparably linked together in a state survey that a bibliography of these subjects must be appended to meet demands and to anticipate wants. Though covering a long list of contributions, it may be condensed into a few lines by simply making reference to certain published lists of writings, and by briefly mentioning certain papers which have a special bearing on the geology of the state.

BOTANICAL BIBLIOGRAPHY OF NEBRASKA

The various botanical contributions to our knowledge of the flora of Nebraska have been compiled by Charles E. Bessey, state botanist, and published in vol. I, 2d ed. of the Phytogeography of Nebraska, under the title Books and Papers Relating Specially to the Flora or to the Phytogeography of Nebraska, pp. 25 to 30, Lincoln, 1900.

ZOOLOGICAL BIBLIOGRAPHY OF NEBRASKA

The various contributions to the knowledge of our fauna have been compiled by Henry B. Ward and published in the Report of the State Board of Agriculture for the year 1898, under the title Zoological Bibliography of Nebraska, Lincoln, 1899, pp. 321 to 338, 3 maps.

ORNITHOLOGY

A bibliography of ornithological papers relating to Nebraska has been prepared by R. H. Wolcott and published in the Proceedings of the Nebraska Ornithologist's Union,

under the title Record of Nebraska Ornithology, pp. 93 to 105, Lincoln, 1902.

GEOLOGICAL BIBLIOGRAPHY OF NEBRASKA

The contributions to the knowledge of the geology of our state have been compiled by E. H. Barbour and Cassius A. Fisher and published in the Annual Report of the State Board of Agriculture for 1901, pp. 248 to 266 inclusive, Lincoln, 1902.

GEOLOGICAL PUBLICATIONS OF IMMEDIATE INTEREST TO CITIZENS

Recent publications by the United States Geological Survey, more especially those of N. H. Darton, are of great importance to the state. The following papers may be consulted with interest and advantage:

DARTON, N. H.—

Catalogue and Index of Contributions to North American Geology, 1732–1891. Bull., U. S. Geol. Survey, No. 127, 1045 pp., 1896.

Underground Waters of a Portion of Southeastern Nebraska. Water-supply and Irrigation Papers, U. S. Geol. Survey, no. 12, pp. 16 to 19, 1898.

Preliminary Report on the Geology and Water-supply of Western Nebraska. 19th An. Rep. U. S. Geol. Survey, pt. 4, pp. 737 to 765, 1899.

Preliminary List of Deep Borings in the United States. Part II (Nebraska-Wyoming). Water-supply and Irrigation Papers of the U. S. Geological Survey, Bull. No. 61.

Geologic folio of the Camp Clarke quadrangle, Nebraska. Folio No. 87, U. S. Geological Survey.

GANNETT, H.—

Dictionary of Altitudes in United States. U. S. Geol. Survey, Bull. 5, pp. 1 to 325, 1884.

Dictionary of Altitudes in United States. U. S. Geol. Survey, Bull. 76, pp. 1 to 393, 1891.

A compilation entitled the Altitudes in Nebraska, by the writer, may be found in the Annual Report of the State Board of Agriculture, 1900, pp. 169 to 180 inclusive.

NEWELL, F. H.—

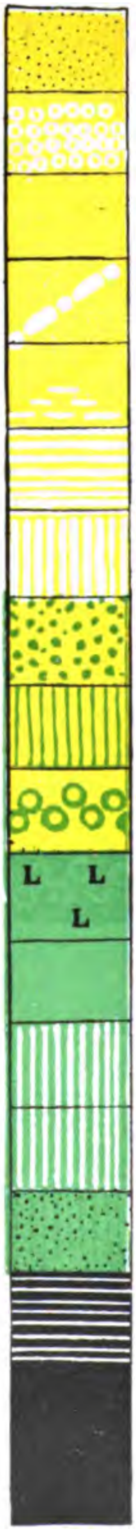
Nebraska. [Artesian wells of Nebraska.] Report on agriculture by irrigation in the western part of the United States, at the eleventh census, 1890, p. 272.

FORTHCOMING REPORTS BY THE STATE GEOLOGICAL SURVEY

The following reports are under preparation and will be issued as rapidly as means will allow:

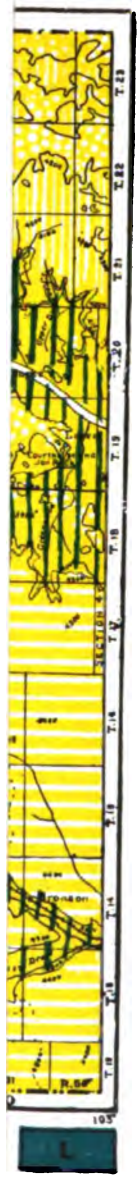
1. The Building Stones of Nebraska.
2. Lime, Plaster, and Cement.
3. Clays and Clay Products.
4. The Flint Industry.
5. Sand and Gravel.
6. Peat Beds of the State.
7. Picturesque Nebraska and the Possibility of Summer Resorts.
8. Water Resources.
9. Mineral Resources.
10. Geological Survey by Counties.
11. Fossils of Nebraska.
12. The fishes of Nebraska both ancient and modern.
13. Strength of our building stones and bricks.

AGE	FORMATION		PREDOMINATING CHARACTER
PLEISTOCENE...	Alluvium..............		Loam, sand, and gravel in valleys, talus on slopes.
	Sand hills		Sand hills, grazing lands.
	Loess		"Yellow clay," fine sandy loam.
	Drift, western limit of ..		Clay, sand, gravel, and bowlders, mostly covered by loess.
	Equus beds.............		Gray sands.
PLIOCENE (?)...	Ogallala formation..........	Loup Fork beds	Calcareous grit, sandy clay, and sand, "Magnesia."
MIOCENE........	Arikaree formation	Loup Fork beds	Gray sand with beds of pipy concretions, butte sands.
	Gering formation.......		Coarse sand, soft sandstone, and conglomerate.
OLIGOCENE......	Brule clay.....	White River Bad Lands	Pinkish clays, hard, and more or less sandy.
	Chadron formation..........	White River Bad Lands	Pale greenish gray sandy clay.
CRETACEOUS....	Laramie................		Shale very limited in area.
	Pierre shale...........		Slate-colored clay or soft shale.
	Niobrara formation.........	Montana group	Chalky limestone and shale.
	Benton chalk and shale	Montana group	Chalky limestone and dark shale.
	Dakota sandstone.......		Rusty sandstone and mottled clay.
CARBONIFEROUS.	Permo-carboniferous ...		Buff limestones and shales.
	Cottonwood limestone...		Massive limestone of light color.
	Atchison shales......... (Wabaunsee)		Limestones, shales, sandstones, and thin coal beds.



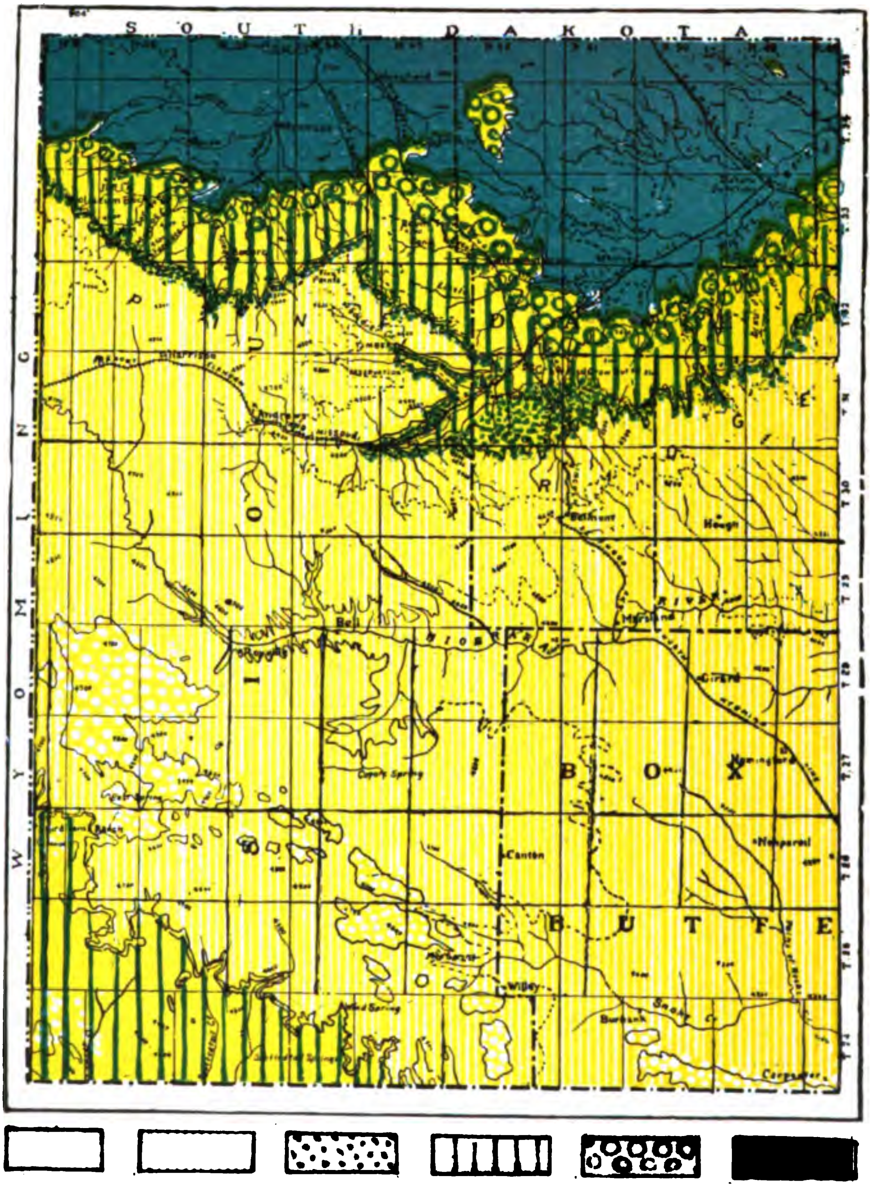
Geological Formations of Nebraska—Explanatory of Plate X

PLATE XI



Laramie
Cretaceous

COUNTIES,



Sand hills *Pleistocene* | Arikaree — *Miocene* — Gering | Brule — *Oligocene (Bad Lands)* — Chadron | Pierre *Cretaceous*

GEOLOGICAL MAP OF SIOUX, DAWES, AND BOX BUTTE COUNTIES, MODIFIED AFTER DARTON

Plates Engraved by U. G. Cornell, University Photographer and Engraver.

JEFFERSON COUNTY

BY F. A. CARMONY

Jefferson county is a level loess plain, cut deeply by the Little Blue river and its tributaries. The surface slopes gradually toward the southeast, the highest elevation, 1,585

Fig. 157.—Exposure of Dakota Cretaceous on the B. & M. R. R. east of Endicott capped with a few feet of drift and loess. Though too soft for building purposes, this rock might be used for sand.

feet, being about two miles northwest of Daykin. From this point the plain extends east to the county line and south along the east line of the county to the state line.

It is cut by the somewhat shallow valleys of Cub and Indian creeks, tributaries of the Big Blue river. The divide in the west between the Little Blue and Rose creek is a portion of the same plain, and has an elevation of 1,540 feet.

The lowest point, about 1,250 feet, is three miles southeast of Steele City.

The Little Blue river has cut its way through this plain to a depth of about 150 feet. Its narrow valley is bordered in some places by steep bluffs into which its small tributaries are slowly cutting their way, forming the hilly portions of the county. At other places the slopes are more gradual and the surface is rolling. Some of the hills that are capped with stone are slightly higher than the surrounding plain.

Fig. 158.—Industrial scene, quarry of Benton limestone on the Blue river six miles northwest of Fairbury and east of the St. J. & G. I. R. R. Stone used for lime, building purposes, and in a limited way for bridges.

There are no depressions except the narrow valleys of the streams.

The valley floor of the Little Blue in the county has a length of about 29 miles and an average width of 1, while the valley floor of the Big Sandy is about 5 miles long and a little more than ½ mile wide.

Rose creek, in the southern part, has a valley 17 miles long and about ½ mile wide, and the valley of Cub creek, in the northeastern part of the county, is about 15 miles long and ½ mile wide.

The principal stream is the Little Blue, running diagon-

ally across the county from northwest to southeast. Big and Little Sandy creeks drain the northwest and Rose creek the southwestern part, while the eastern and northeastern parts are drained by Indian creek and Cub creek, tributaries of the Big Blue. The streams flow rapidly and furnish excellent water power.

The geological formations in the county, as shown by exposures, are Dakota Cretaceous, Benton, Glacial Drift, Loess, and Alluvium.

The Dakota is characterized, beginning at lower stratum, by sand, always water-bearing, and the water frequently

Fig. 159.—Industrial scene, sand and gravel pit on the B. & M. R. R. ½ mile west of Kesterson. Glacial gravel 30 to 40 feet deep at the opening and exposed for 200 yards, capped with loess.

salt or alkaline, mottled clay, and sand rock. The first stratum is reached only in deep wells, and it has been impossible to procure definite information as to its thickness. The clay varies in thickness from a few feet to 180 feet. On top of this is sand rock, in some places 125 feet in thickness. The rock lies conformably on the clay and is well stratified. The first and third cut on the B. & M. R. R. east of Endicott show distinct cross-bedding.

The strata of this epoch dip quite perceptibly to the west

and underlie every part of the county. Some of the sand rock is quite rich in fossils.

The Benton Cretaceous consists of a layer of shale from 20 to 200 feet thick capped with lime rock, in some places 30 feet thick. The rock is composed largely of marine shells. It consists of four or five layers of moderately hard rock from 8 to 10 inches thick, separated by layers of softer material 4 to 5 feet in thickness. This deposit underlies the western part of the county and is exposed in many places by erosion. Very little water is found in it. About 1½ miles east of Powell a thin vein of coal is found in the Benton Cretaceous.

The glacial drift consists of a bluish clay, boulders, and sand, oftentimes mixed indiscriminately, but many almost clear beds of sand and gravel occur, and in some places boulders are found alone, the other material having been eroded. The drift is exposed wherever the loess is eroded, except in the southern portion. There are no surface indications of drift on the elevated portion of the country south of Rose creek. The beds vary in thickness from a few inches to 100 feet.

The sand is stratified and layers vary from fine to coarse and are frequently cross-bedded. When this overlies Dakota it usually contains good water, but overlying the Benton, water is not so likely to be found.

The most common boulders are the pink Sioux quartzite, but in the southeastern part of the county (in T. 1, R. 4 E.) the gray is much more common.

The loess mantle is complete except in the hilly section where it has been eroded. It is a yellow clay, columnar in structure, and in places contains considerable gravel mixed through it. It varies in thickness from 1 to 100 feet, and forms the basis of the farming lands of the county. It contains little or no water.

Very narrow belts of alluvium are found along all of the streams. It is shallow and is not important compared with the other formations of the county.

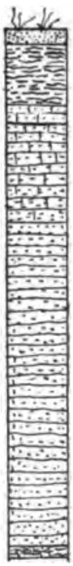


Fig. 160.—Section of the well of William Bodaye, Richland, town 2, range 2, section 21. Depth of well 131 feet, 30 feet of water.

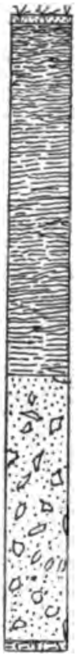


Fig. 161.—Section of well at Jansen, Neb., town 3, range 3, section 34, 164 feet deep, water shallow.

Fig. 162.—Section of well of Elias Weiker, range 1, section 10, 252 feet deep, 90 feet of water.

	ft.	ft.
Soil	8	8
Loess	52	60
Drift: Sand and gravel	70	130
Dakota: Clay, gravel, and sand, water-bearing	180	310

Fig. 163.—Section of Ed. Wells' 310-foot well, range 3, Jefferson county, Neb., 175 feet of water.

	ft.	ft.
Soil	2	2
Loess	6	8
Drift: Sand and gravel	61	69

Fig. 164. — Section of Alex Shepherd's well, Endicott, Neb., town 1, range 3, section 16, 9 feet of water.

	ft.	
Loess	2	2
Sand	16	18
Clay	3	21
Drift: Sand	69	90

Fig. 165. — Section of F. A. Carmony's well at Fairbury, town 2, range 2, section 14, S.W.¼, 90 feet deep, 6 feet of water.

	ft.	
Soil	8	8
Loess	80	88
Drift	42	130

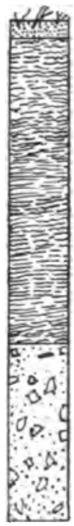


Fig. 166. — Section at Cyrus Wolfe's well, Plymouth, Jefferson county, Neb., town 4, range 4, section 32, well 130 feet deep, 6 feet of water.

ECONOMIC GEOLOGY OF JEFFERSON COUNTY

The Dakota furnishes a fair quality of building stone. Many foundations and some entire buildings have been constructed of it. The principal quarries are south of Fairbury and east of Endicott.

The clay makes excellent tiling, pottery, and brick. A Beatrice firm, a few years ago, shipped over a thousand carloads from Endicott, which they made into an excellent quality of tiling. A company at Hastings is now shipping, from a pit three miles east of Endicott, ten carloads a week, which it is making into brick. Some of the more ochreous clay has been used with considerable success as a body for paint.

The Benton, east of Powell and also south of Thompson, furnishes a quantity of lime or chalk rock. It is used quite extensively for building purposes, and a fair quality of lime has been made from it.

The quartzite of the glacial drift is a very durable rock, and is somewhat used in foundations, but the sand and gravel of this epoch are of the most value. Two miles west of Fairbury on the C., R. I. & P. R. R. the company has a sand and gravel pit which it has worked for the past eight years, during which time they have shipped an average of about three cars a day for plastering, cement, and ballast.

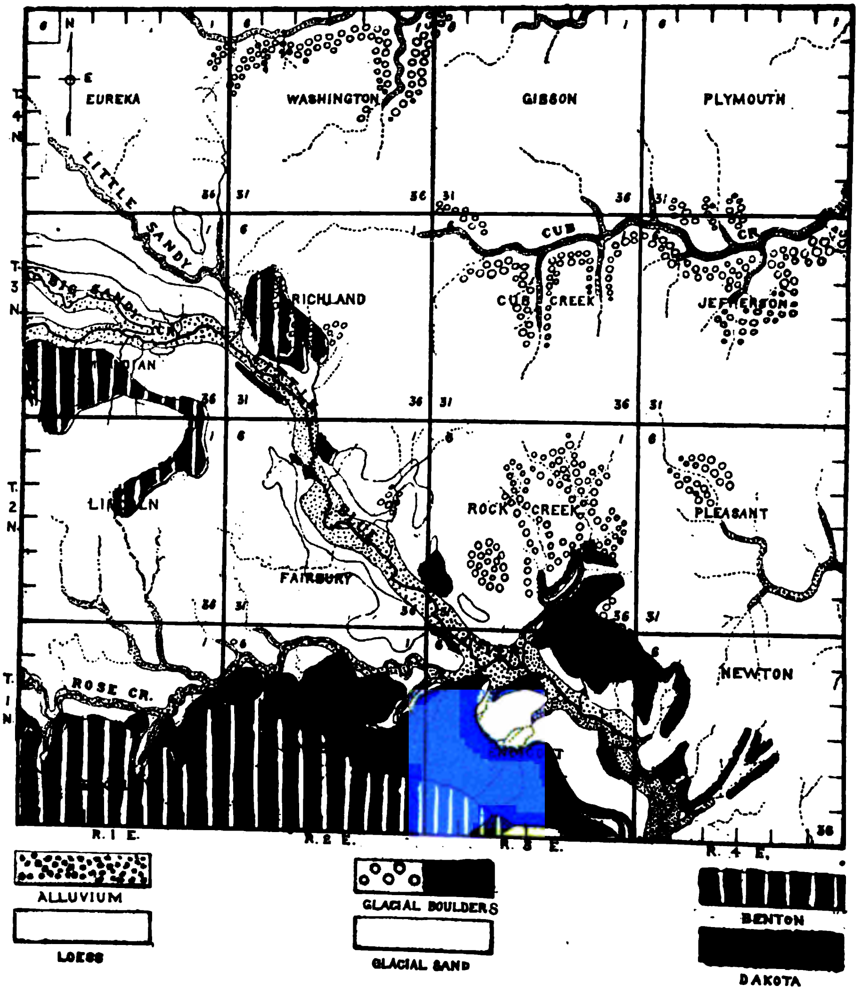
On the B. & M. R. R., one-half mile west of Kesterson, is a pit which they have worked quite regularly for the past fifteen years, using most of the sand for ballast, but they are now using it for cement work. Fairbury and vicinity get most of their sand from a pit just east of the city limits.

Loess is used for making brick at Fairbury, and is important in its relation to the agriculture of the county.

RECORDED WELLS OF JEFFERSON COUNTY, NEB.

(Arranged alphabetically by post-offices)

POST-OFFICE	LOCATION S. T. R.	OWNER	Depth	Feet of water	STRATA PASSED THROUGH
Daykin....	30-4 n.-1 e.	Art Woodman	62	4	2 ft. loess, 14 ft. sand, 6 or 8 ft. reddish-yellow sand rock.
do	27-4 n.-1 e.	H. J. Newell........	?	9	
do	....	Tom Barber.........	150	10	20 ft. loess, light clay. Lower down mixed with stones, then sand, then gravel.
do	26-4 n.-1 e.	Frank Hellwig......	96	......	
do	....	Public well	167	7	Soil, 5 ft.; loess, 55 ft.; glacial drift, clay, and gravel, 100 ft.; sand, 7 ft.
do	12-4-1	H. W. Schiermeyer.	99	......	
do	15-4-1	Postmaster	140	......	
Endicott ..	16-1-3	Alex. Shepherd.....	68	9	Soil, 2 ft.; loess, 6 ft.; sand and gravel, 60 ft.
do	3-1-3	J. O. Boggs	81	45	Soil, 4 ft: loess, 10 ft.; Dakota clay, 66 ft.; sand, 1 ft.
do	3-2-2	E. C. Case...........	......	Spr'g	Comes out of white soft sand rock at base of red sand rock bluff 80 ft. high.
Fairbury..	14 s.w.-2-2	F. A. Carmony	90	6	Loess, 2 ft; sand, 16; clay, 3; sand, 69, all glacial.
do	21-2-2	J. C. Kesterson	......	Spr'g	Rises from glacial drift sand at base of loess bluff 25 ft. high.
Gladstone.	3-2-1	S. F. Schwitter	200	20	Soil, clay, limestone, shale.
do	10-2-1	Aug. Stark	185	......	
do	10-2-1	Postmaster	188	8	Soil, clay, rock, shale, and sandstone.
do	32-3-1	A. M. Akin	106	16	20 ft. limestone; 70 blue shale; 16 sandstone.
do	10-2-1	A. B. Ude....... ...	190	10	
Harbine...	10-3-4	Jas. Wrigley........	115	20	Quicksand.
do	4-2-4	John Wiese	125	20	Loess, except 5 ft. black clay and 3 ft. glacial sand.
do	28-3-4	Public well	122	4	Loess except 3 ft. of sand at bottom.
do	10-2-4	J. R. Spicer	40	18	Loess and 4 ft. of sand.
do	....	Postmaster	122	12	
Jansen	34-3-3	....	160	Sev'l.	Soil, 4 ft.; loess, 100 ft.; glacial sand, 56 feet.
do	34-3-3	....	164	Shal.	Soil, 4 ft.; loess, 100 ft.; clay and gravel glacial drift, 59 ft.; 1 ft. Dakota sand rock.
Lincoln ...	10-0-1	Elias Weiker........	252	90	25 ft. soil; 25 ft. limestone; 100 ft. shale; 100 ft. soapstone, sandstone, water.
Plymouth.	32-4-4	Cyrus Wolfe........	130	6	8 ft. soil; 80 ft. loess; 42 ft. glacial drift.
do	21-4-4 n.	Postmaster, '96	44	4	
Powell ...	21-3-1	Gregor Landkamer.	18	7	Hard pan.
Richland..	21-2-2	Wm. Bodaye........	135	30	20 ft. soil; 30 ft. lime rock; 60 ft. shale; 20 ft. soapstone, sandstone, water.
	0-2-3	Ed Wells............	310	175	60 ft. loess; soil 70; sand and gravel, 180; fire clay, gravel and sand, water.



GEOLOGICAL MAP OF JEFFERSON COUNTY, NEBRASKA

Plates Engraved by U. G. Cornell, University Photographer and Engraver

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ERRATA

On page 90 under Howard county, Howard should read Dannebrog.
Fig. 105, Auburn should read Verdon.
Fig. 82, mountains should read mountain.
Page 128, Steblotrypa should read Streblotrypa.
Page 175, second line from bottom, Pils. should read Mull.